

Title: On the 2-vector re-formulation of quantum mechanics

Date: Sep 30, 2009 02:00 PM

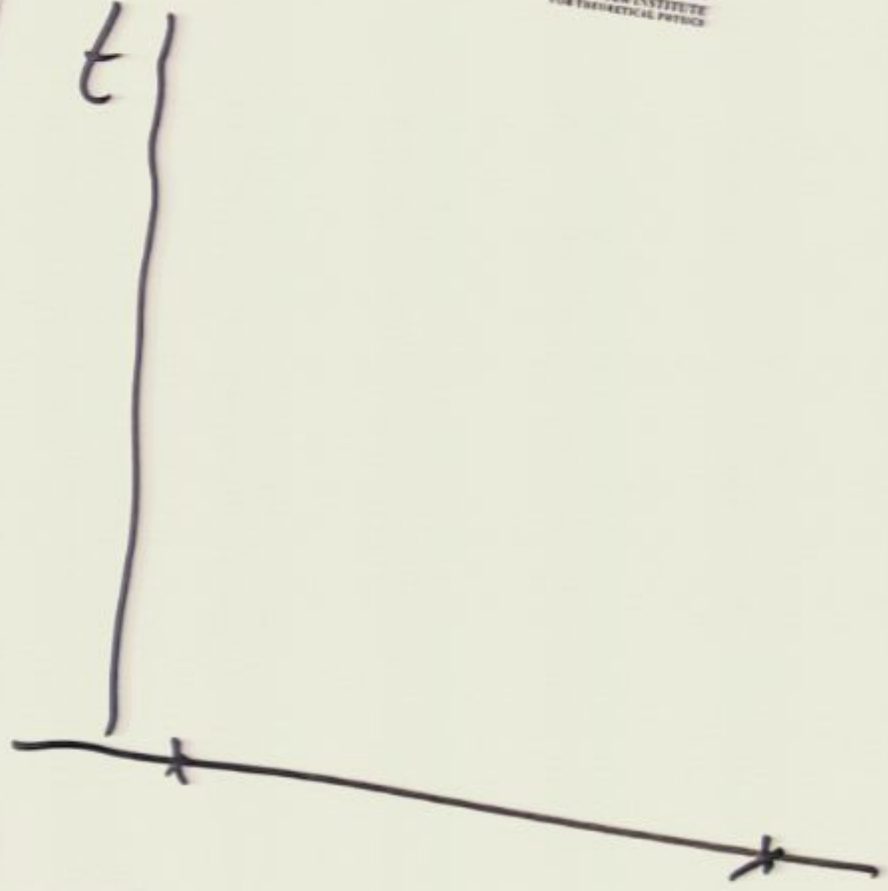
URL: <http://pirsa.org/09100096>

Abstract: I will discuss properties of pre- and post-selected ensembles in quantum mechanics. I will also discuss the proper way to observe these properties through the use of a new type of non-disturbing measurement which I call 'weak measurement'. A number of these new experiments have already been successfully performed and others are in the planning stage. These experiments have confirmed the unique property of pre- and post-selected ensembles that I call 'weak values.' Theoretical analysis of the outcomes of these experiments have produced several very rich results. First, it has shed new light on the most puzzling features of quantum mechanics, such as interference, entanglement, etc. Secondly, it has uncovered a host of new quantum phenomena, which were previously hidden.&quot;



$t$  |

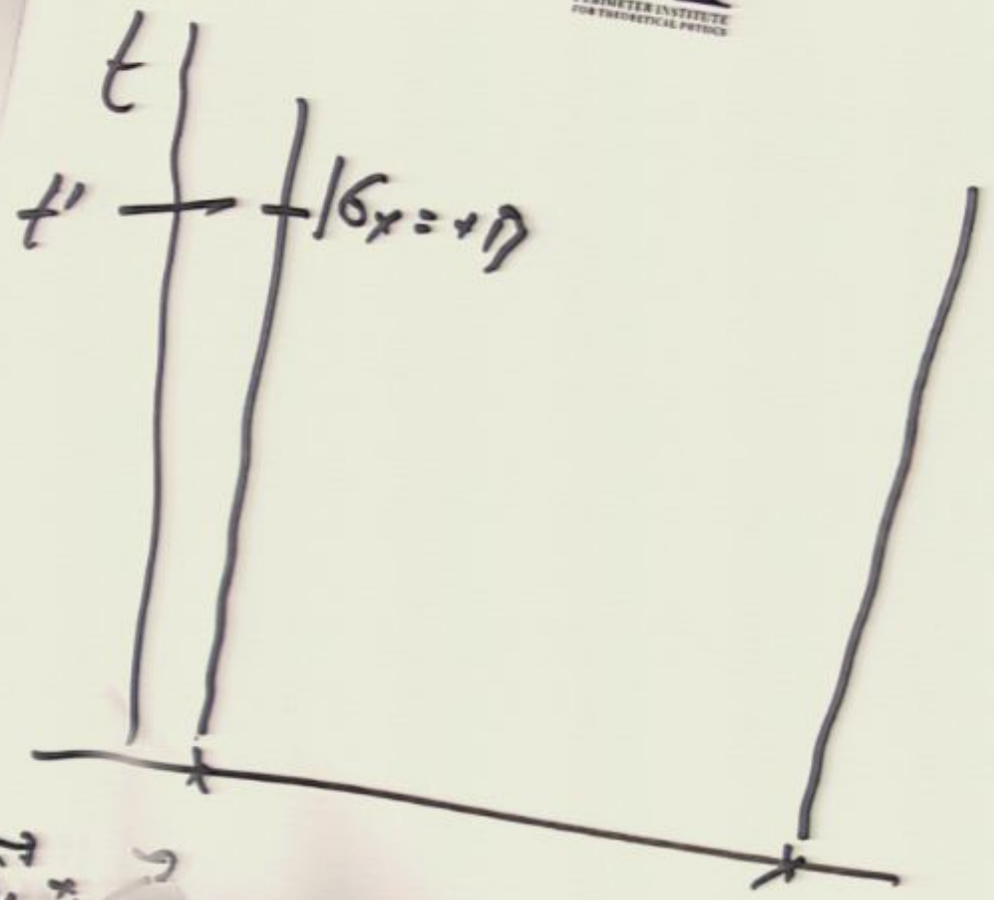
$\epsilon$



$\epsilon$



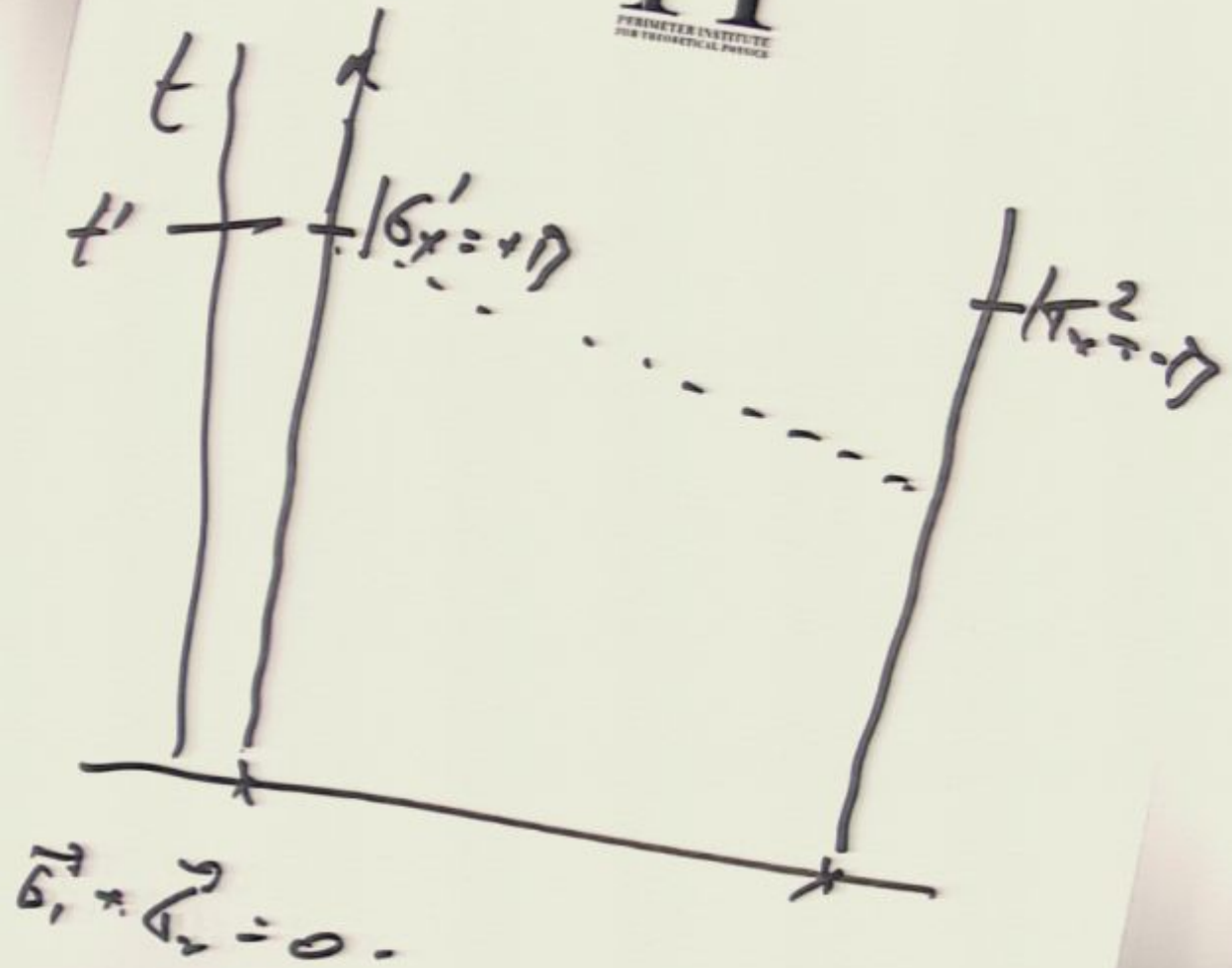
$$\vec{\Delta}_1 + \vec{\Delta}_2 = 0.$$

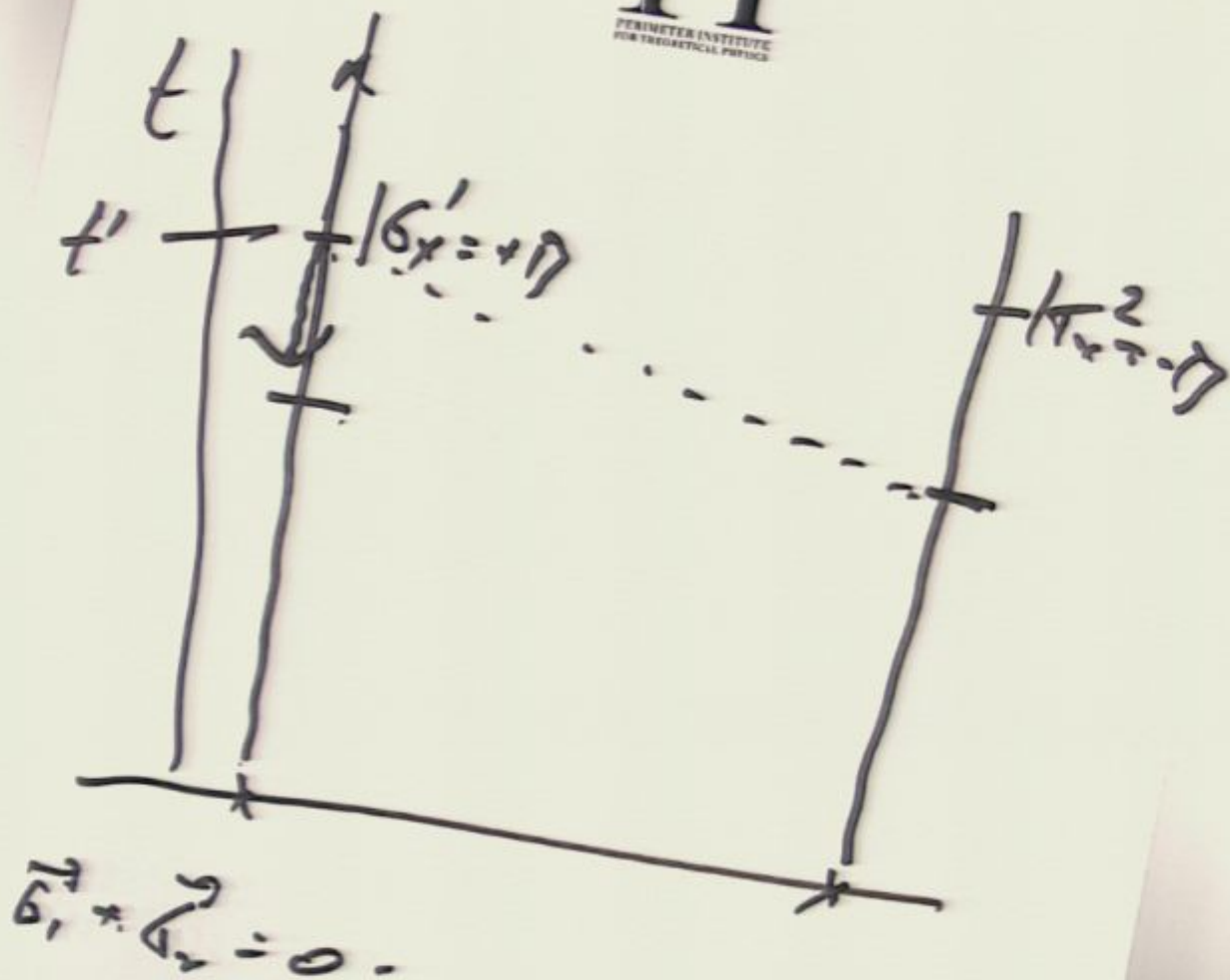


$\Delta t = 0$



$$\Delta_1 + \Delta_2 = 0.$$







11

6, 1/2

$$t_2 \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}}$$

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$$t_1 \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}}$$

$d_2$  1/2  $d_1$

—

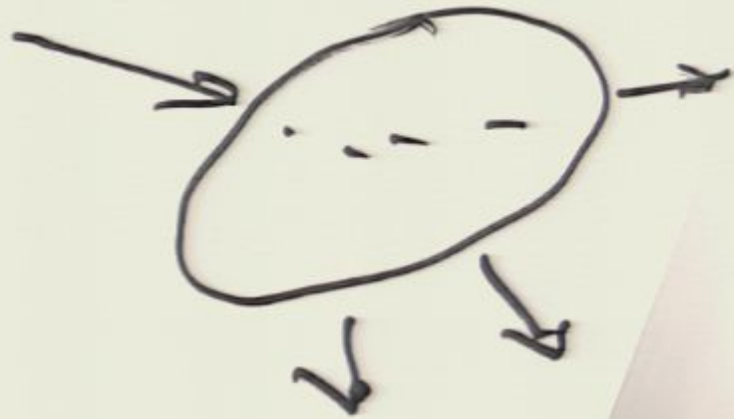
$d_1$  1/2  $d_2$



$d_2$   $\frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}}$

—

$d_1$   $\frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}}$



$d_e$   $\frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}}$

—

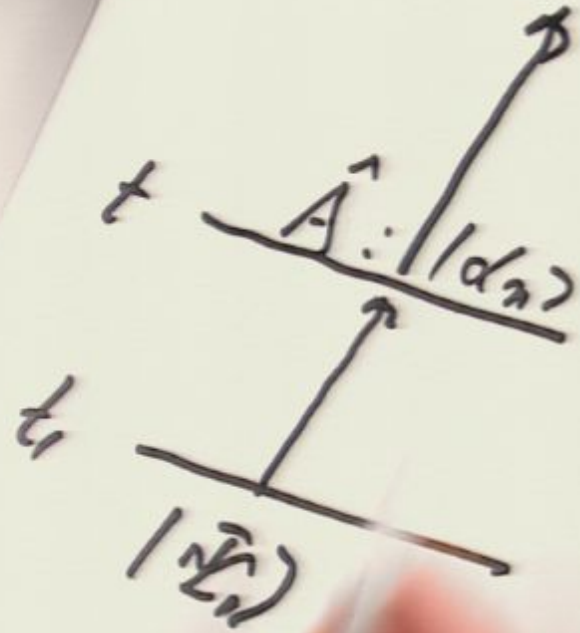
$d_i$   $\frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}}$



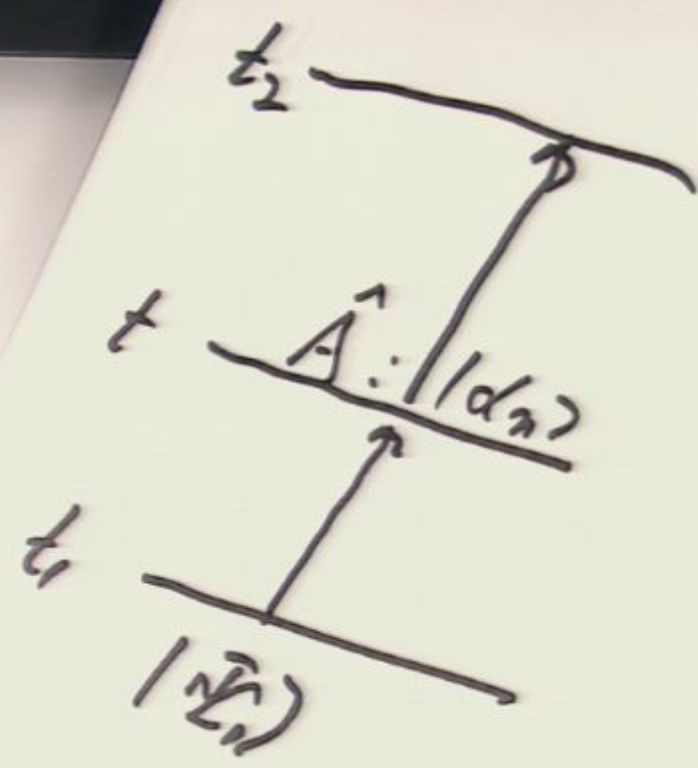


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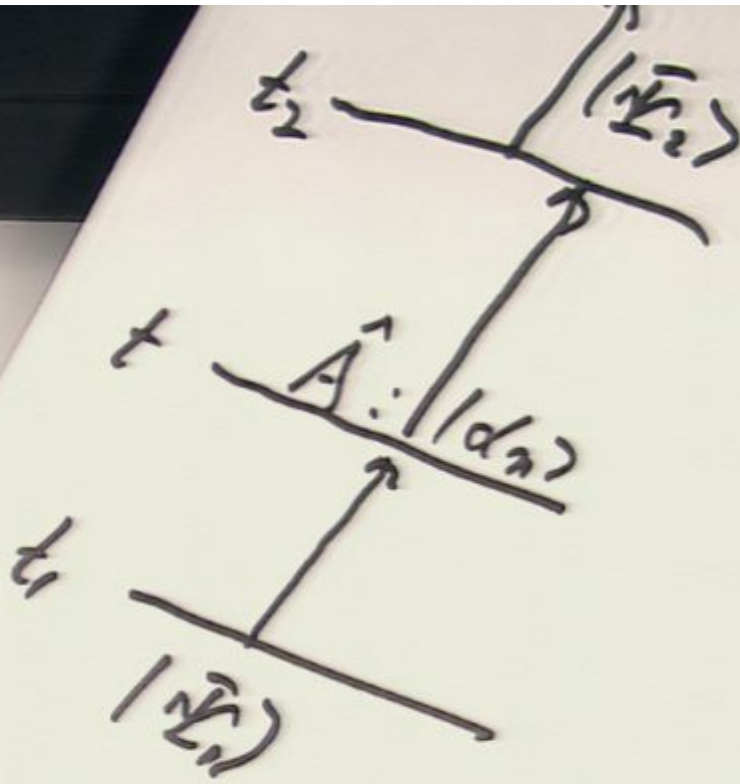


$$\vec{A} \cdot |\vec{d}_n\rangle = |\vec{A}| \cos \theta$$



$$A |dn\rangle = a_n |a_n\rangle$$





$$\hat{A} |d_n\rangle = \text{const} |d_n\rangle$$



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$\langle \psi | U | \psi \rangle \langle \psi | U | \psi \rangle$   
 $\langle \psi | U | \psi \rangle \langle \psi | U | \psi \rangle$

11-14-61  
HIT



$\langle \psi | U_{\Delta} | \psi \rangle$   
"Can.  
|Can/2  
 $\langle \psi | U_{\Delta} | \psi \rangle$

er-HL-61  
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0-14(1-6)  
+14  
= Can.  
1 Can.  
Pr (dm)

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11-14(2-6)  
7/11

$$\left( \frac{U+}{t_2} \mid dm \right) \left( dm \mid U, \frac{1}{t_2} \right) = \text{Can.}$$

$$\left( \text{Can} \mid U \right) P_r(dm)$$

$$\left( U+ \frac{1}{t_2} \mid dm \right) \left( dm \mid U, \frac{1}{t_2} \right) = \text{Can.}$$

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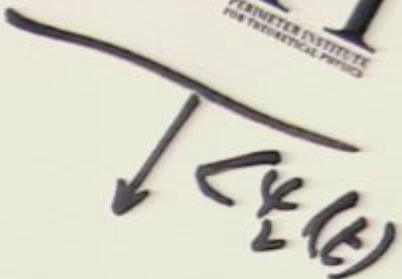


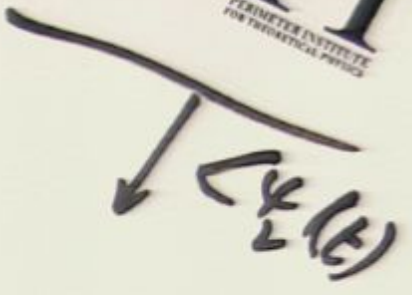


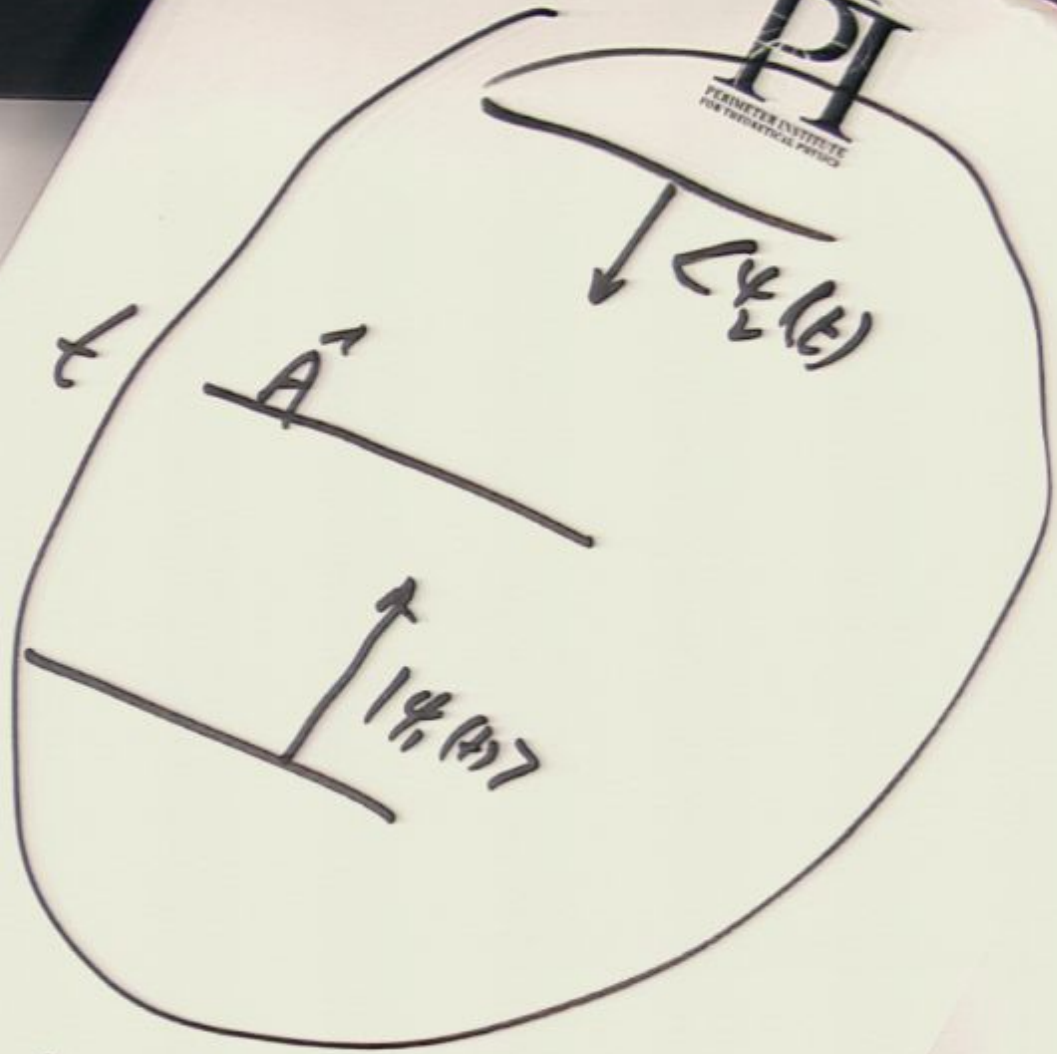
$f$   $A^{\rightarrow}$

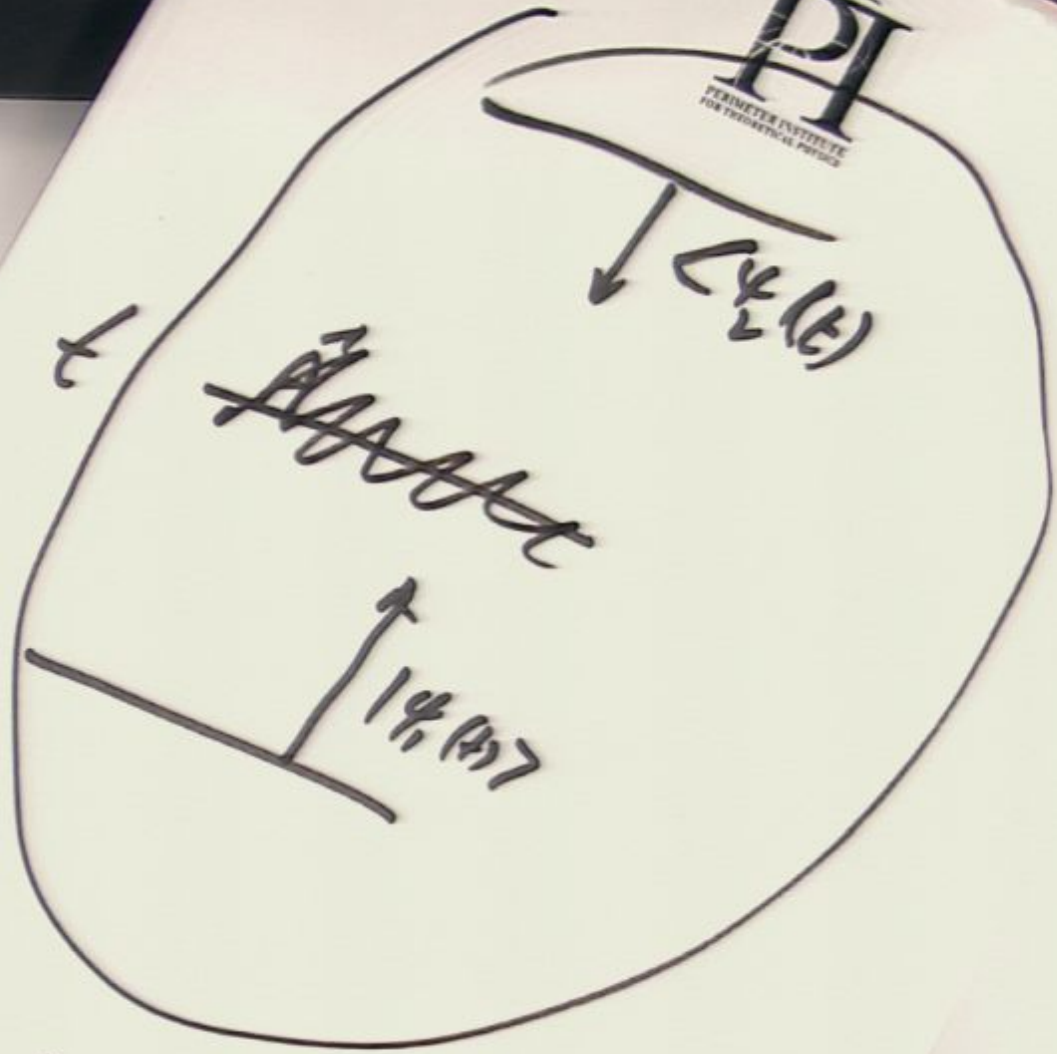
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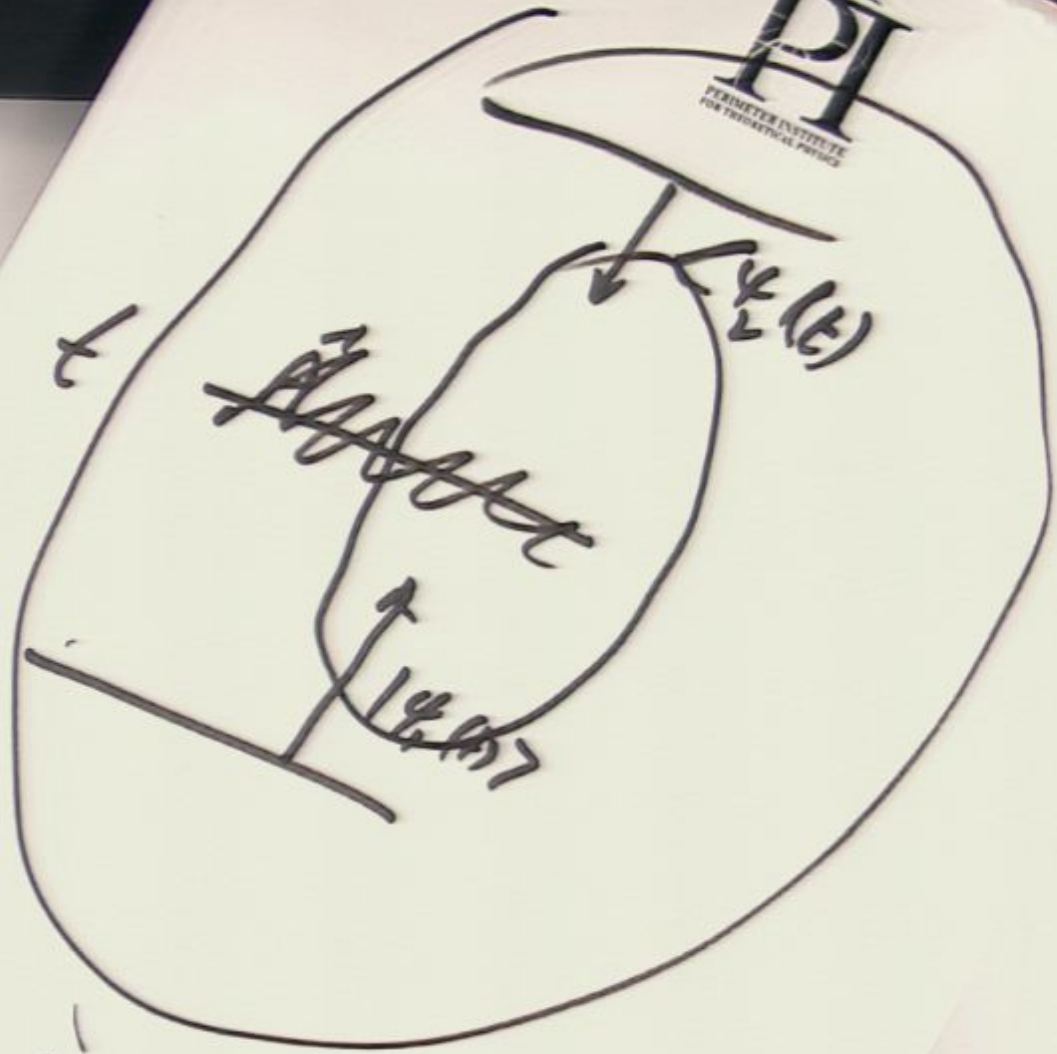
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$$e^{-i\frac{H}{\hbar}(t-t_1)}$$

$$\langle \Psi_2 | U_{t_2, t_1} | \alpha_m \rangle \langle \alpha_m | U_{t_1, t_0} | \Psi_1 \rangle$$

$$= c_m \cdot |c_m|^2$$

$$Pr(\alpha_m)$$

$$\langle \Psi_2 | U_{t_2, t_1} | \alpha_m \rangle \langle \alpha_m | U_{t_1, t_0} | \Psi_1 \rangle = c_m$$

$$e^{-i\frac{H}{\hbar}(t-t_1)}$$

$$\langle \Psi_2 | U_{t_2 t_1} | \alpha_m \rangle \langle \alpha_m | U_{t_1 t_0} | \Psi_1 \rangle$$

$$= c_m \cdot |c_m|^2$$

$$Pr(\alpha_m)$$

$$\langle U_{t_2 t_1}^\dagger \Psi_2 | \alpha_m \rangle \langle \alpha_m | U_{t_1 t_0} | \Psi_1 \rangle = c_m$$






A single horizontal line drawn on the paper.


$$t_2 \quad \frac{16y = +17}{\underline{\hspace{2cm}}}$$

$$t_1 \quad \frac{\hspace{2cm}}{16x = +17}$$


$t_2$   $\overline{16y = +17}$




$t_1$   $\overline{16x = +17}$



$t_2$   $16y = +17$




$t_1$   $16x = +17$




$16x + 16y$

$t_2$   $|\psi_y = +1\rangle$




$t_1$   $|\psi_x = +1\rangle$




$|\psi_x = +1\rangle$   
 $|\psi_y = +1\rangle$

$t_2$   $16y = +17$



$t_1$   $16x = +17$

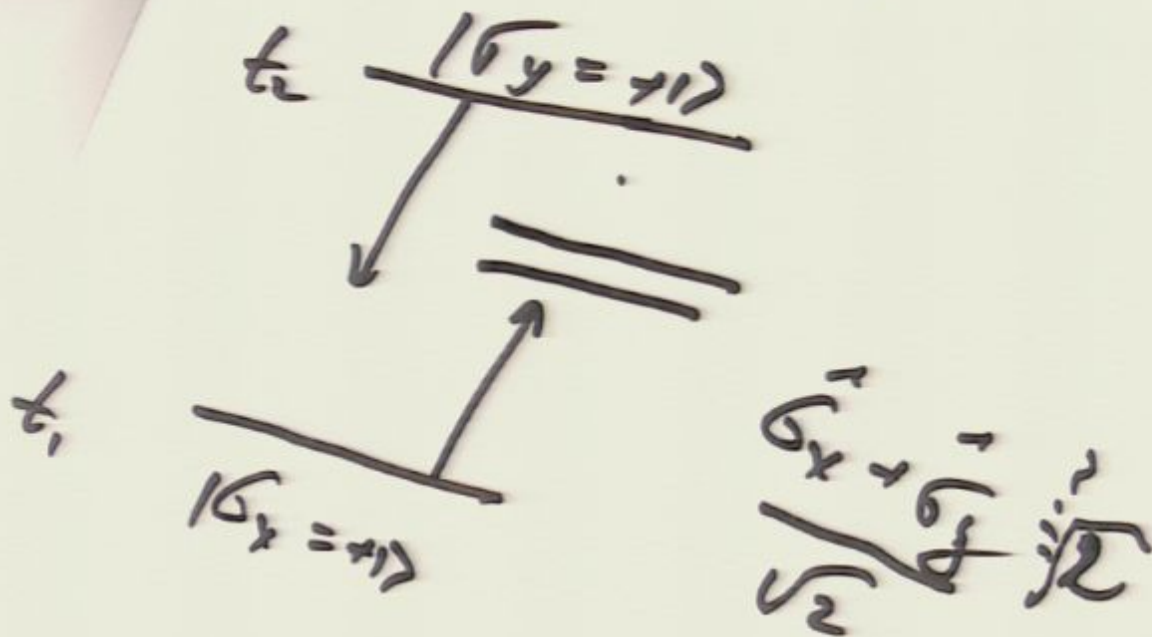


$G_x = \frac{1}{16}$   
 $G_y = \frac{1}{16}$

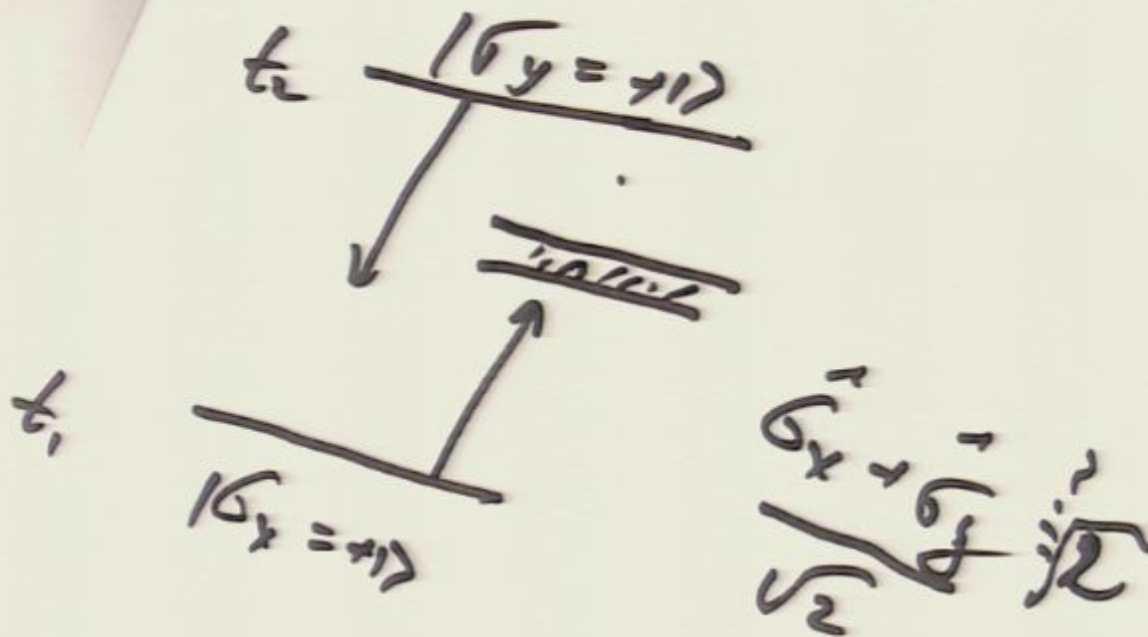
$t_2$   $\frac{16y = +17}{\text{---}}$

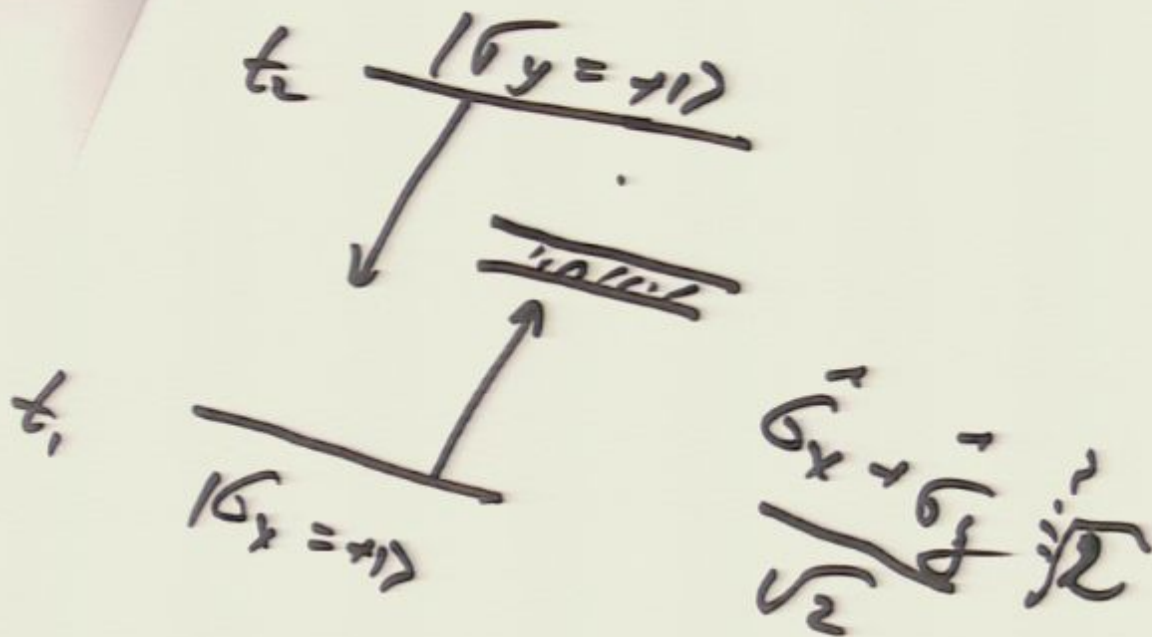
$t_1$   $\frac{16x = +17}{\text{---}}$

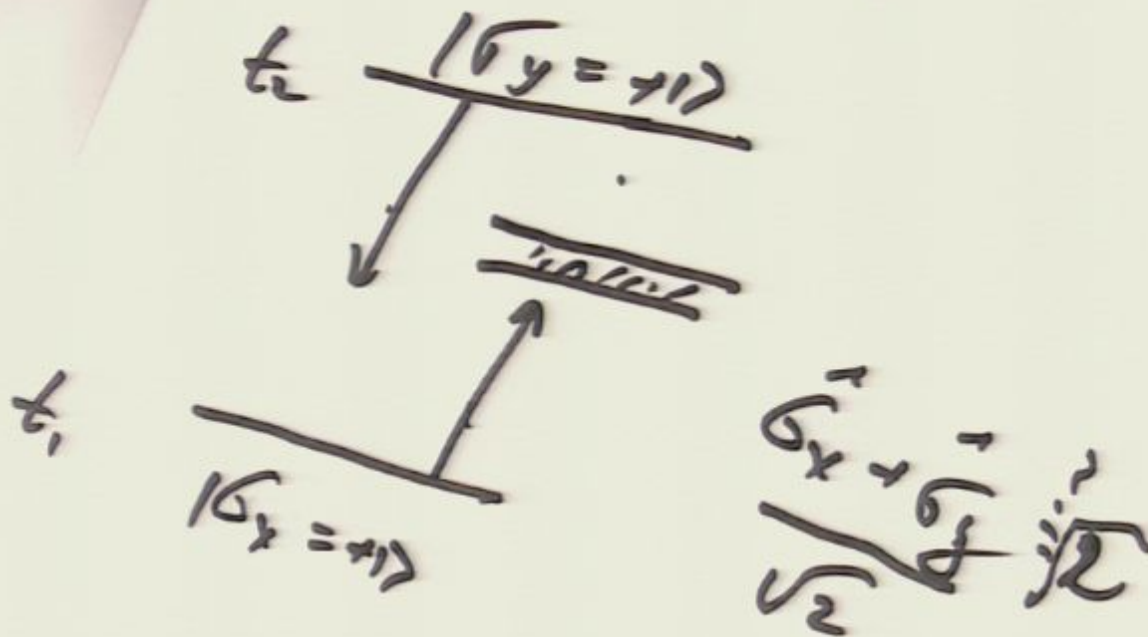
$\frac{16x + 16y}{\sqrt{2}}$

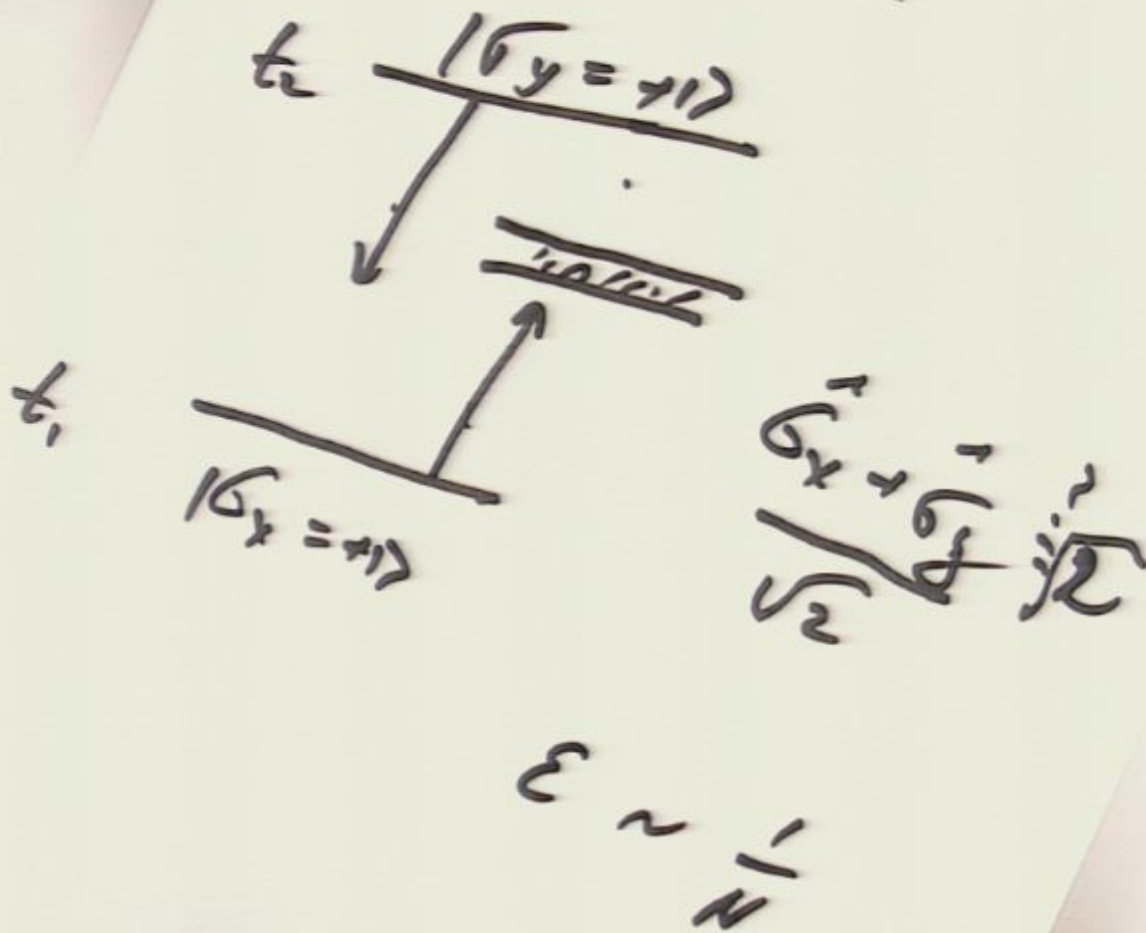


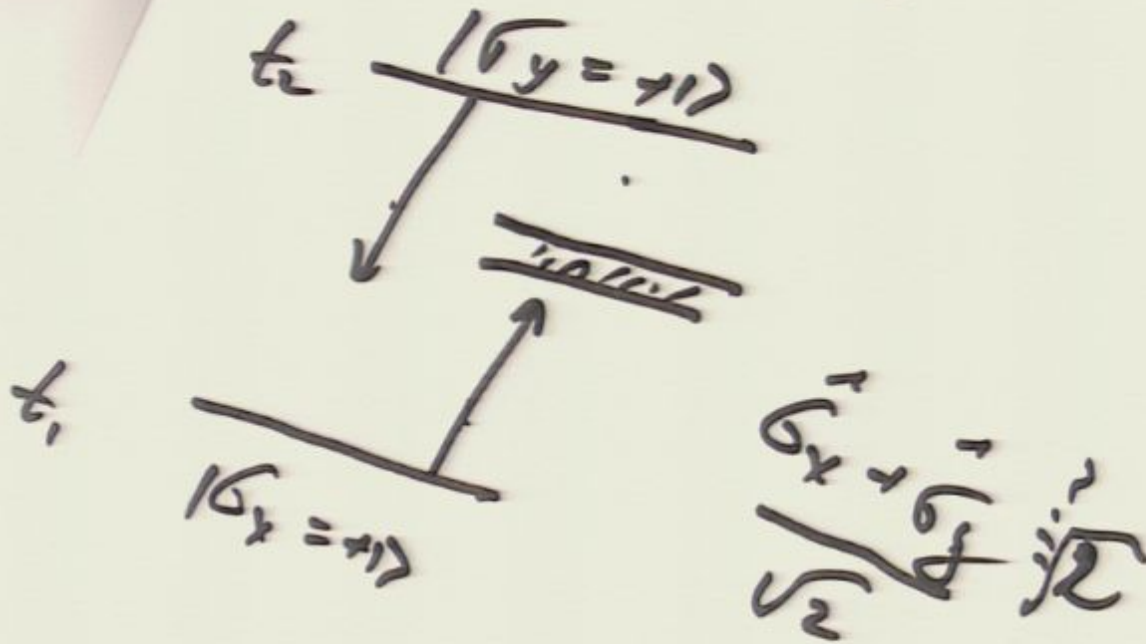












A/ST





$$\vec{A}(\vec{x}) = \int d^3y$$



$$\vec{A}(\vec{x}) = \int \frac{d^3k}{(2\pi)^3} \frac{e^{i\vec{k}\cdot\vec{x}}}{k^2} = \frac{1}{4\pi r}$$

where  $r = |\vec{x}|$





$$A^{\rightarrow} / \mathcal{K} = \mathcal{K} / \mathcal{K} = a / \mathcal{K}$$

$$\mathcal{K} / A^{\rightarrow} \mathcal{K} = a = A$$

$$= a / \mathcal{K}$$

$$\hat{A}|\psi\rangle = \sqrt{E}\psi = a|\psi\rangle$$

$$= b|\psi\rangle$$

$$\langle\psi|\hat{A}|\psi\rangle = a = \bar{A}$$

$$\langle\psi|\hat{A}^2|\psi\rangle = a^2 + \sigma^2$$

$$\hat{A}^T / \hat{A} = \sqrt{\hat{A}^T} = a / \hat{A}$$

$$\sqrt{\hat{A}^T / \hat{A}^T} = a = \hat{A}$$

$$\sqrt{\hat{A}^T / \hat{A}^T} = a^2 = \hat{A}^T$$

$$= \hat{A} / \hat{A}^T$$

$$A^{\dagger} | \psi \rangle = | \psi \rangle = a | \psi \rangle$$

$$\langle \psi | A^{\dagger} | \psi \rangle = a \langle \psi | \psi \rangle$$

$$\langle \psi | A^{\dagger} | \psi \rangle = a \langle \psi | \psi \rangle$$

$$\langle \psi | A^{\dagger} | \psi \rangle = a \langle \psi | \psi \rangle$$

$$= a \langle \psi | \psi \rangle$$

$$= a \langle \psi | \psi \rangle$$

A(N)



$$\vec{A}(N) = \vec{A}(N) + \Delta A(N)$$

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$$\hat{A}(N) = \bar{A}(N) + \Delta A(N)$$

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$$\vec{A}(\vec{x}) = \vec{A}(\vec{x}) + \nabla\phi(\vec{x})$$

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$$\vec{A}(\vec{x}) = \vec{A}(\vec{x}) + \nabla\phi(\vec{x})$$

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$\vec{A}(N) = A(N) + \Delta A(N)$

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$\vec{A}(N) = A(N) + \Delta A(N)$

$\vec{A}(N) = A(N) + \Delta A(N)$

$\vec{A}(N) = A(N) + \Delta A(N)$

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$\vec{A} = A_1 \hat{i} + A_2 \hat{j} + A_3 \hat{k}$

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$\vec{A} = A_1 \hat{i} + A_2 \hat{j} + A_3 \hat{k}$

$\vec{A} = A_1 \hat{i} + A_2 \hat{j} + A_3 \hat{k}$

$\vec{A} = A_1 \hat{i} + A_2 \hat{j} + A_3 \hat{k}$

$\vec{A} = A_1 \hat{i} + A_2 \hat{j} + A_3 \hat{k}$

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$\vec{A} = A_1 \hat{i} + A_2 \hat{j} + A_3 \hat{k}$   
 $\vec{B} = B_1 \hat{i} + B_2 \hat{j} + B_3 \hat{k}$   
 $\vec{A} + \vec{B} = (A_1 + B_1)\hat{i} + (A_2 + B_2)\hat{j} + (A_3 + B_3)\hat{k}$

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$\vec{A} = A_1 \hat{i} + A_2 \hat{j} + A_3 \hat{k}$   
 $\vec{B} = B_1 \hat{i} + B_2 \hat{j} + B_3 \hat{k}$   
 $\vec{A} + \vec{B} = (A_1 + B_1) \hat{i} + (A_2 + B_2) \hat{j} + (A_3 + B_3) \hat{k}$   
 $\vec{A} - \vec{B} = (A_1 - B_1) \hat{i} + (A_2 - B_2) \hat{j} + (A_3 - B_3) \hat{k}$

**P**  
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$\psi(x)$



$\psi(x).$   
          

$\psi^*(x)\psi(x).$



$$\psi(x)$$

$$\psi^*(x)\psi(x)$$

$$\psi^*(x_1)\psi(x_1) = \psi^*(x_1)\psi(x_1)$$



$$\frac{1}{N} \sum \vec{A}_n \cdot |\Psi\rangle$$

$$\vec{A}_n \cdot |\Psi_{\text{tot}}\rangle = 0$$

$$\frac{1}{N} \sum \hat{A}_n^2 |\mathcal{E}\rangle$$

$$\hat{A}_n |\hat{\mathcal{E}}_{tot}\rangle = \sum_{m \neq n} \psi(m) [ ]$$

$$\frac{1}{N} \sum \hat{A}_n |\Psi\rangle$$

$$\hat{A}_n |\hat{\Psi}_{\text{tot}}\rangle = \sum_{m \neq n} \psi(m) [ ]$$

$$\hat{A}_n |\psi(m)\rangle = \bar{A} |\psi(m)\rangle + \Delta A |\psi_n^{\perp}\rangle$$



$(\sqrt{2})^2 = 2AA$



$$(\delta \mathcal{H}) = \sum_A \delta A \sum_H \delta H$$



$(\mathcal{N} = 4)$

$2 \times 2$

$\mathcal{N} = 4$   
 $(\mathcal{N} = 4)$

$(\mathcal{N} = 4)$

$$\langle \psi | \psi \rangle = \sum_i A_i A_i$$

$$\langle \psi | \psi \rangle = \sum_i H_{ii}$$

$$\langle \psi | \psi \rangle = \frac{(\psi | \psi)}{N}$$



$$f(\mathcal{N}) = \sum A^A$$

$$\langle f(\mathcal{N}) \rangle = \sum H(\mathcal{N})$$

$$\frac{(\mathcal{N})^2}{\mathcal{N}^2} \rightarrow \frac{(\mathcal{N})^2}{\mathcal{N}^2}$$

$$\langle \sqrt{N} \rangle = \sum_A \frac{1}{Z} \sum_{\mu} \sqrt{H(\mu)}$$

$$\langle \sqrt{N} \rangle \langle \sqrt{N} \rangle = \frac{(\langle N \rangle)^2}{N} \quad N \rightarrow \langle N \rangle^2$$

$\rightarrow 0.$   
 $N \rightarrow \infty$





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سید آیدین



Handwritten text in Devanagari script, likely a name or address, written on a piece of paper placed over a document.



$$\langle \Psi | \hat{A} | \Psi \rangle$$

$$= \langle \Psi | \Phi_n \rangle \langle \Phi_n | \hat{A} | \Psi \rangle$$

$$= \langle \Psi | \Phi_n \rangle \langle \Phi_n | \Psi \rangle \frac{\langle \Phi_n | \hat{A} | \Psi \rangle}{\langle \Phi_n | \Psi \rangle}$$



$$\langle \Psi | \hat{A} | \Psi \rangle$$

$$= \int \langle \Psi | \Phi_n \rangle \langle \Phi_n | \hat{A} | \Psi \rangle$$

$$= \int \langle \Psi | \Phi_n \rangle \langle \Phi_n | \Psi \rangle \frac{\langle \Phi_n | \hat{A} | \Psi \rangle}{\langle \Phi_n | \Psi \rangle}$$

$$\langle \Psi | \hat{A} | \Psi \rangle$$

$$= \int \langle \Psi | \Phi_n \rangle \langle \Phi_n | \hat{A} | \Psi \rangle$$

$$= \int \langle \Psi | \Phi_n \rangle \langle \Phi_n | \Psi \rangle \frac{\langle \Phi_n | \hat{A} | \Psi \rangle}{\langle \Phi_n | \Psi \rangle}$$

Aw =





$$A_w = \sqrt{\frac{2}{\pi}} \left( \frac{2\pi}{\sqrt{3}} \right)$$



$$A_{\omega} = \frac{\langle \vec{e}_i | \hat{A} | \vec{e}_i \rangle}{\langle \psi | \psi \rangle}$$



$$A_{\omega} = \frac{\langle \psi | \hat{A} | \psi \rangle}{\langle \psi | \psi \rangle}$$

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$$e^{i\theta \hat{A}} | \psi \rangle / \langle \psi |$$

$$A_{\omega} = \frac{\langle \psi | \hat{A} | \psi \rangle}{\langle \psi | \psi \rangle}$$

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$$e^{i g \hat{A}} | \psi \rangle | \psi \rangle$$

$$e^{i 19 \hat{A}}$$

$$A_{\omega} = \frac{\langle \Psi | \hat{A} | \Psi \rangle}{\langle \Psi | \Psi \rangle}$$


---

$$e^{i\eta \hat{A}} | \Psi \rangle | \Psi \rangle$$

$$e^{i\lambda \eta \hat{A}} = 1 + i\lambda \eta \hat{A}$$



$$\langle \psi_2 | e^{i\lambda g \hat{A}} | \psi_1 \rangle / \langle \psi | \psi \rangle$$

$$A_\omega = \frac{\langle \psi | \hat{A} | \psi \rangle}{\langle \psi | \psi \rangle}$$

$$e^{i g \hat{A}} | \psi \rangle / \langle \psi | \psi \rangle$$

$$e^{i\lambda g \hat{A}} = 1 + i\lambda g \hat{A}$$

$$\langle \hat{N}_2 | e^{i\lambda \hat{A}} | \hat{N}_1 \rangle / \langle \hat{N} \rangle$$

$$A_\omega = \frac{\langle \hat{N} | \hat{A} | \hat{N} \rangle}{\langle \hat{N} | \hat{N} \rangle}$$

$$e^{i\lambda \hat{A}} | \hat{N} \rangle / \langle \hat{N} |$$

$$e^{i\lambda \hat{A}} = 1 + i\lambda \hat{A}$$

$$\langle \tilde{\psi}_2 | e^{i\lambda g \hat{A}} | \tilde{\psi}_1 \rangle / \langle \tilde{\psi} | \tilde{\psi} \rangle$$

$$\langle \psi_2 | 1 + i\lambda g \hat{A} | \psi_1 \rangle$$

$$A_\omega = \frac{\langle \tilde{\psi} | \hat{A} | \tilde{\psi} \rangle}{\langle \tilde{\psi} | \tilde{\psi} \rangle}$$

$$e^{i g \hat{A}} | \psi \rangle / \langle \tilde{\psi} |$$

$$e^{i\lambda g \hat{A}} = 1 + i\lambda g \hat{A}$$

$$\langle \underline{N}_2 | e^{i\lambda g \hat{A}} | \underline{N}_1 \rangle | \underline{E} \rangle$$

$$\langle \psi_2 | 1 + i\lambda g \hat{A} | \psi_1 \rangle$$

$$= \langle \psi_2 | \psi_1 \rangle \left( 1 + i\lambda g \frac{\langle \psi_1 | \hat{A} | \psi_1 \rangle}{\langle \psi_1 | \psi_1 \rangle} \right)$$

$$A_\omega = \frac{\langle \underline{E} | \hat{A} | \underline{E} \rangle}{\langle \psi_1 | \psi_1 \rangle}$$

$$e^{i g \hat{A}} | \psi \rangle | \underline{E} \rangle$$

$$e^{i \lambda g \hat{A}}$$

$$= 1 + i \lambda g \hat{A}$$

$$\langle \underline{n}_2 | e^{i\lambda g \hat{A}} | \underline{n}_1 \rangle / \langle \underline{n} | \underline{n} \rangle$$

$$\langle \psi_2 | 1 + i\lambda g \hat{A} | \psi_1 \rangle$$

$$= \langle \underline{\psi}_2 | \underline{\psi}_1 \rangle \left( 1 + i\lambda g \frac{\langle \psi_2 | \hat{A} | \psi_1 \rangle}{\langle \psi_2 | \psi_1 \rangle} \right)$$

$$= e^{i\lambda g A_w}$$

$$A_w = \frac{\langle \underline{n} | \hat{A} | \underline{n} \rangle}{\langle \underline{\psi} | \underline{\psi} \rangle}$$

$$e^{i g \hat{A}} | \psi \rangle / \langle \underline{n} | \underline{n} \rangle$$

$$e^{i\lambda g \hat{A}} = 1 + i\lambda g \hat{A}$$

$$\langle \underline{\psi}_2 | e^{i\lambda g \hat{A}} | \underline{\psi}_1 \rangle / \langle \underline{\psi} | \underline{\psi} \rangle$$

$$\langle \psi_2 | 1 + i\lambda g \hat{A} | \psi_1 \rangle$$

$$= \langle \underline{\psi}_1 | \underline{\psi}_1 \rangle (1 + i\lambda g \frac{\langle \psi_2 \hat{A} \psi_1 \rangle}{\langle \psi_2 | \psi_1 \rangle})$$

$$= e^{i\lambda g A_w}$$

$$A_w = \frac{\langle \underline{\psi} | \hat{A} | \underline{\psi} \rangle}{\langle \underline{\psi} | \underline{\psi} \rangle}$$

$$e^{i g \hat{A}} | \psi \rangle / \langle \underline{\psi} | \underline{\psi} \rangle$$

$$e^{i\lambda g \hat{A}} = 1 + i\lambda g \hat{A}$$

$$\langle \tilde{\psi}_2 | e^{i\lambda g \hat{A}} | \tilde{\psi}_1 \rangle | \tilde{\psi} \rangle$$

$$\langle \psi_2 | 1 + i\lambda g \hat{A}^2 | \psi \rangle$$

$$= \langle \psi_2 | \psi \rangle (1 + i\lambda g \frac{\langle \psi_2 \hat{A}^2 \psi \rangle}{\langle \psi_2 | \psi \rangle})$$

$$= e^{i\lambda g A_w}$$

$$A_w = \frac{\langle \tilde{\psi} | \hat{A} | \tilde{\psi} \rangle}{\langle \tilde{\psi} | \tilde{\psi} \rangle}$$

$$e^{i g \hat{A}} | \psi \rangle | \tilde{\psi} \rangle$$

$$e^{i\lambda g \hat{A}} = 1 + i\lambda g \hat{A}$$

$$A_\omega \equiv \frac{\langle \psi_2 | \hat{A} | \psi_1 \rangle}{\langle \psi_2 | \psi_1 \rangle}$$



$$A_{\omega} \equiv \frac{\langle \psi_2 | \hat{A} | \psi_1 \rangle}{\langle \psi_2 | \psi_1 \rangle}$$

$$A_\omega \equiv \frac{\langle \psi_2 | \hat{A} | \psi_1 \rangle}{\langle \psi_2 | \psi_1 \rangle}$$

$$\frac{x \rightarrow x + i\epsilon_0}{\partial \frac{\delta^2}{\partial x^2}}$$

$$A_\omega \equiv \frac{\langle \psi_2 | \hat{A} | \psi_1 \rangle}{\langle \psi_2 | \psi_1 \rangle}$$

$$\underline{x \rightarrow x + it_0}$$

$$e^{-\frac{x^2}{2\sigma^2}} \rightarrow e^{-\frac{(x + it_0)^2}{2\sigma^2}}$$

$$e^{-\frac{1}{2}x^2}$$

$$A_\omega \equiv \frac{\langle \psi_2 | \hat{A} | \psi_1 \rangle}{\langle \psi_2 | \psi_1 \rangle}$$

$$\frac{x \rightarrow x + i\lambda_0}{\hline \hline}$$

$$e^{-\frac{1}{2}x^2} \rightarrow e^{-\frac{1}{2}(x + i\lambda_0)^2}$$

$$e^{-\frac{x^2}{2\sigma^2}} e^{i k x_0}$$


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$$A_\omega \equiv \frac{\langle \psi_2 | \hat{A} | \psi_1 \rangle}{\langle \psi_2 | \psi_1 \rangle}$$

$$x \rightarrow x + i k_0$$


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$$e^{-\frac{x^2}{2\sigma^2}} \rightarrow e^{-\frac{(x + i k_0)^2}{2\sigma^2}}$$

$$e \cdot A_\omega \equiv \frac{\langle \psi_1 | \hat{A} | \psi_1 \rangle}{\langle \psi_1 | \psi_1 \rangle}$$

$$\frac{x \rightarrow x + i t_0}{\dots}$$

$$e^{-\frac{\hat{A}}{\hbar}} \rightarrow e^{-\frac{(x + i t_0) \hat{A}}{\hbar}}$$



$$e^{-\frac{x^2}{2\sigma^2}} e^{i k x}$$

---

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H

$e^{i\pi/2} = i$   
 $e^{i\pi} = -1$   
 $e^{i3\pi/2} = -i$   
 $e^{i2\pi} = 1$

---

$i$     $-1$     $-i$

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$$e^{-\frac{x^2}{2\sigma^2}} e^{i k x}$$


---

$$\begin{array}{ccc}
 \square & \square & \square \\
 \frac{1}{\sqrt{2\pi}} & + \frac{1}{\sqrt{2}} & + \frac{1}{\sqrt{2}}
 \end{array}$$

$$e^{-\frac{x^2}{2\sigma^2}} e^{i k x}$$


---

$$\begin{array}{ccc}
 \square & \square & \square \\
 \frac{1}{\sqrt{2\pi}} & + \frac{1}{\sqrt{2}} & + \frac{1}{\sqrt{3}}
 \end{array}$$



$$\begin{matrix} \square & \square & \square \\ \gamma & + \gamma & + \gamma \end{matrix}$$



$$\left( \frac{4}{6} + \frac{4}{2} - \frac{4}{3} \right) \frac{1}{5}$$

$$\square \quad \square \quad \square \quad \frac{1}{5}$$

$$\epsilon_1 + \square \quad \square \quad \square$$

$$\left( \frac{4}{6} + \frac{4}{2} + \frac{4}{3} \right) \frac{1}{5}$$

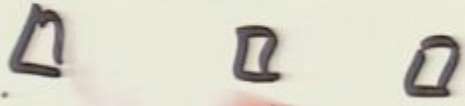
$$\begin{array}{l}
 \frac{6}{2} \\
 \hline
 (4 + 4 - 4) \frac{1}{3} \\
 0 \quad 0 \quad 0
 \end{array}$$

$$0 \quad 0 \quad 0$$

$$\begin{array}{l}
 4 + 4 - 4 \\
 \hline
 (4 + 4 + 4) \frac{1}{3}
 \end{array}$$



$$\left( \frac{4}{3}, \frac{4}{3}, -\frac{4}{3} \right), \frac{1}{\sqrt{3}}$$



$$\left( \frac{4}{3}, \frac{4}{3}, -\frac{4}{3} \right)$$

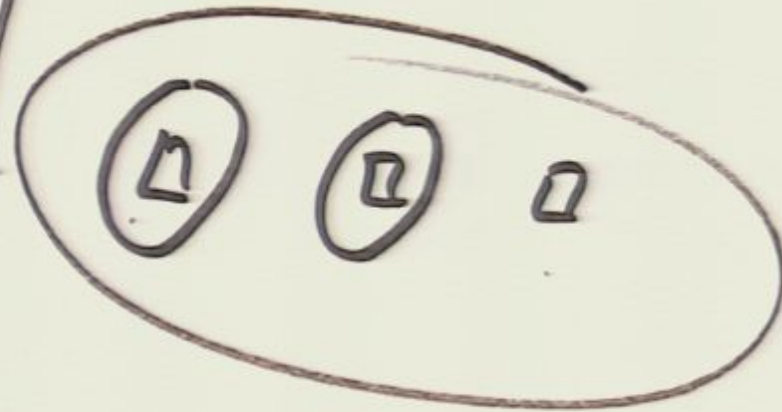
$\frac{6}{2}$

$(\frac{4}{1} + \frac{4}{2} - \frac{4}{3}) \frac{1}{5/3}$

$(\frac{4}{1}) (\frac{4}{2}) (\frac{4}{3})$

$\frac{6}{2} (\frac{4}{1} + \frac{4}{2} + \frac{4}{3}) \frac{1}{5/3}$

$\frac{6}{2}$ 
  
 $(\frac{4}{1} + \frac{4}{2} - \frac{4}{3}) \frac{1}{5/3}$ 
  
 $\square \quad \square \quad \square$



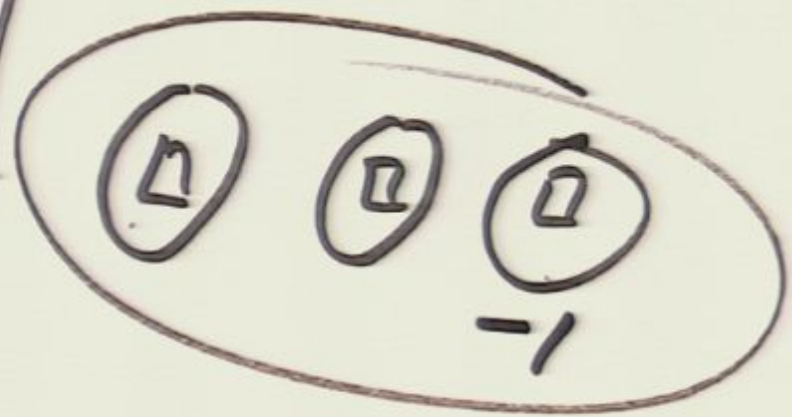
$\frac{6}{2}$ 
  
 $(\frac{4}{1} + \frac{4}{2} + \frac{4}{3}) \frac{1}{5/3}$ 
  
 $\square \quad \square \quad \square$





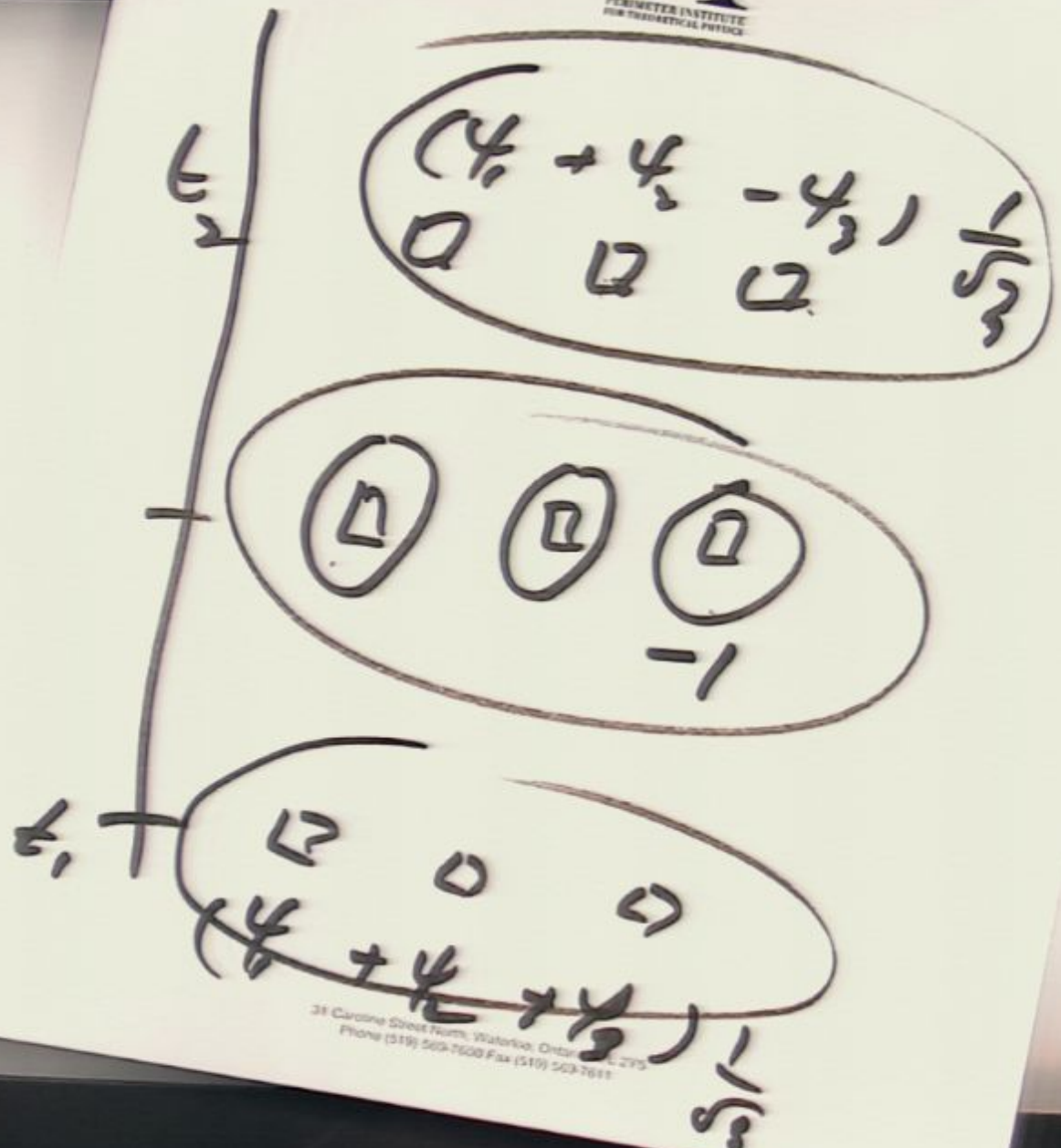
$$\left( \frac{4}{6} + \frac{4}{3} - \frac{4}{3} \right) \frac{1}{5}$$

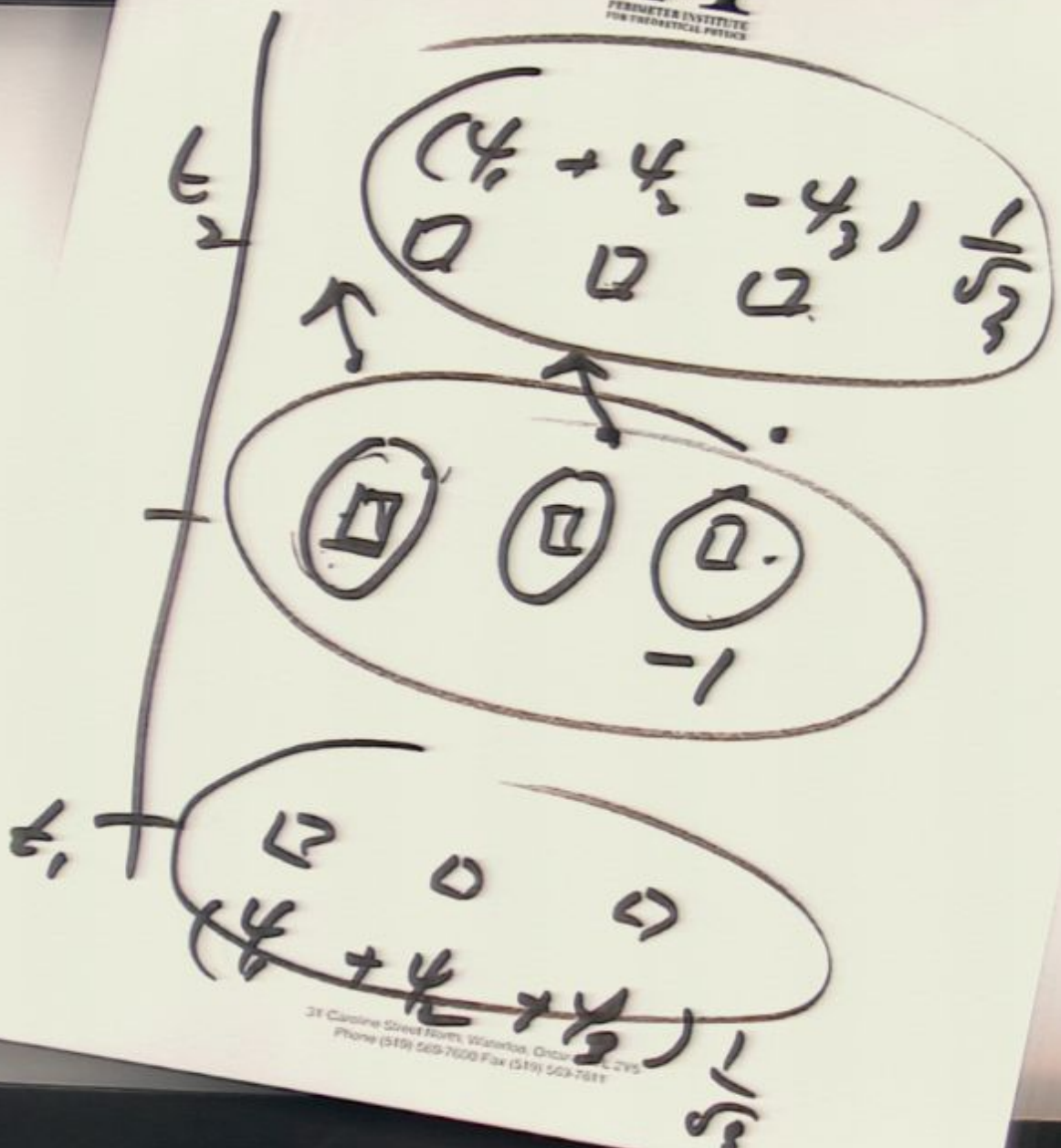
$\square \quad \square \quad \square$



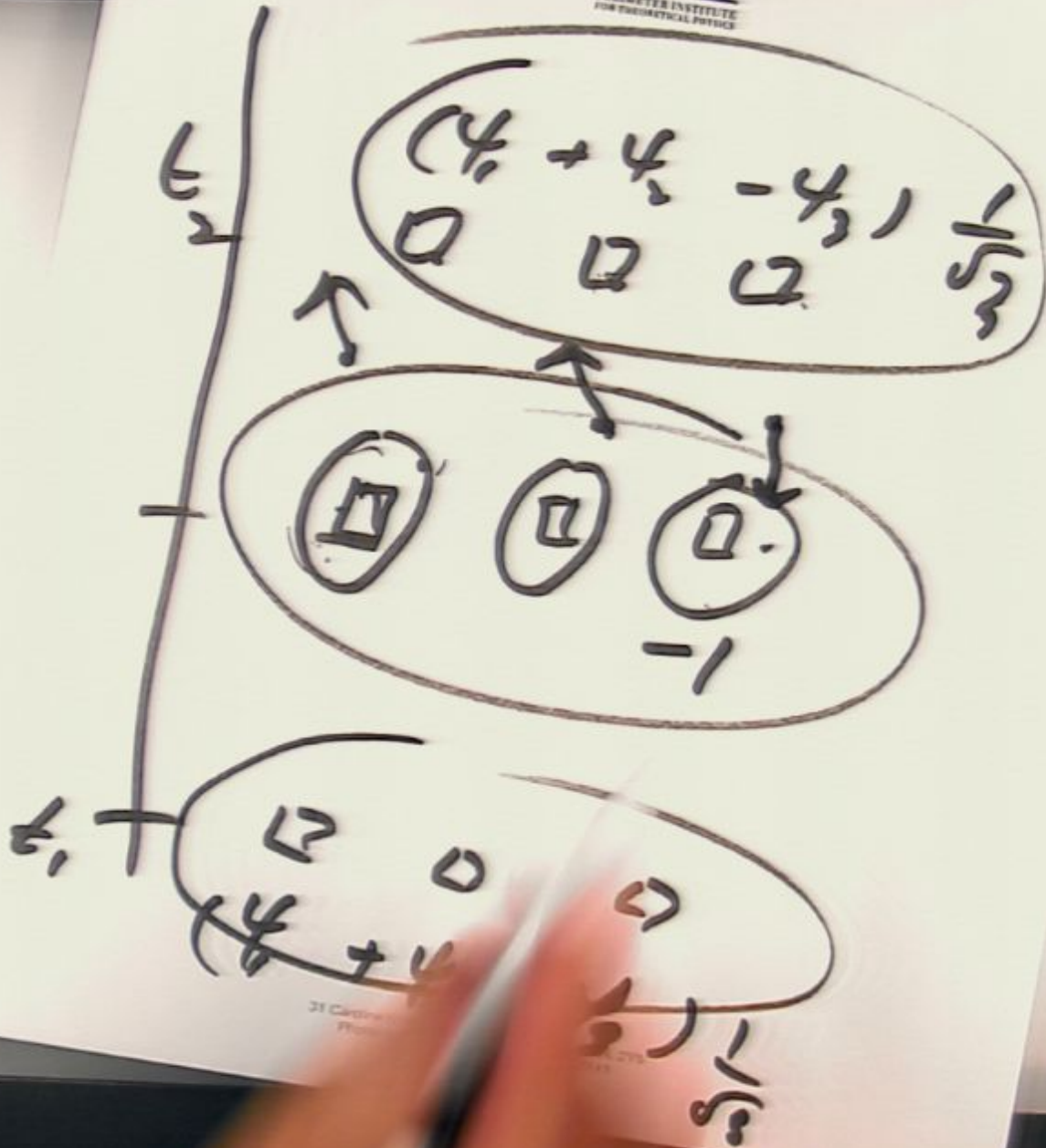
$\leftarrow$ ,  $\rightarrow$   $\square \quad \square \quad \square$

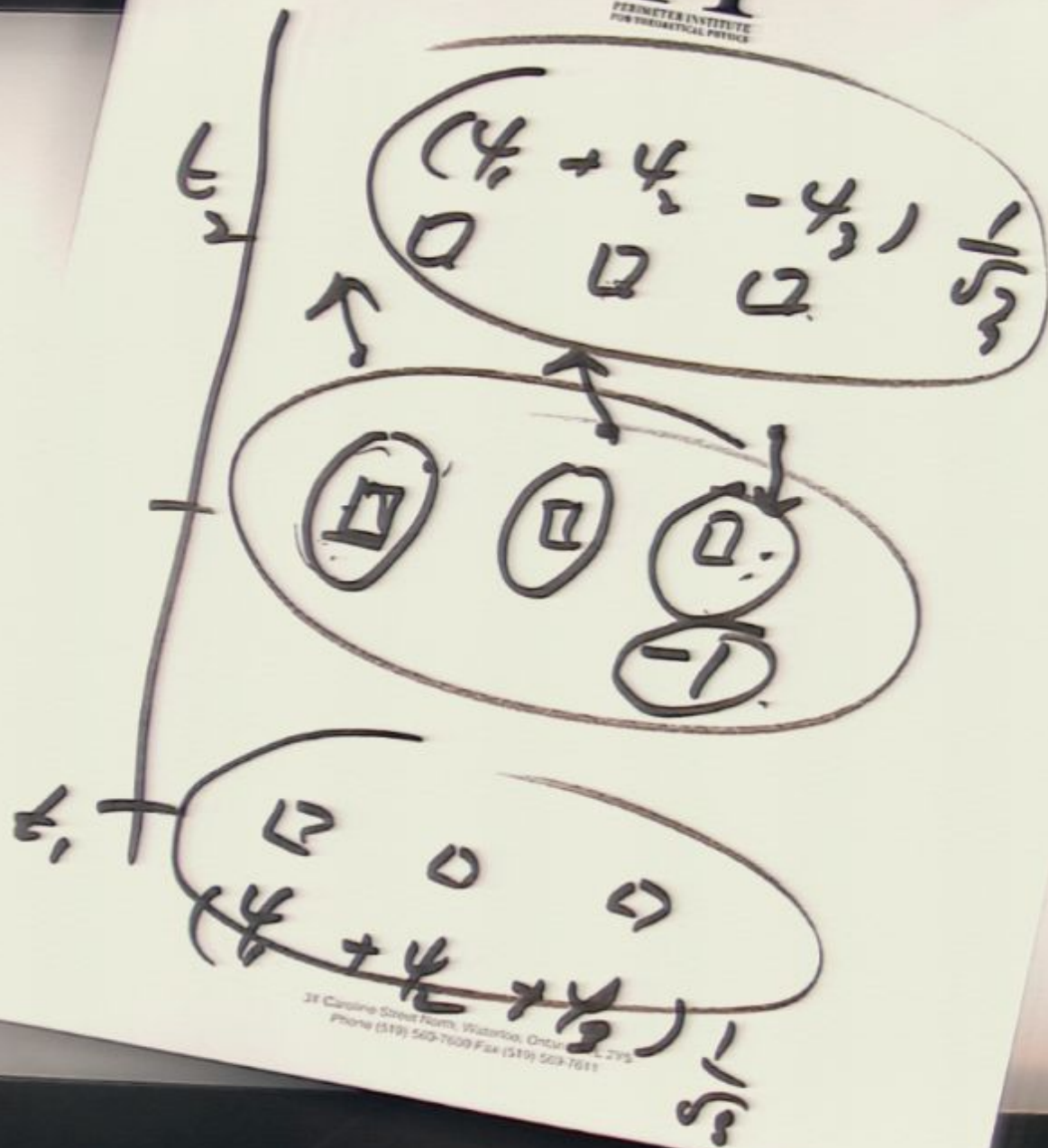
$$\left( \frac{4}{6} + \frac{4}{3} + \frac{4}{3} \right) \frac{1}{5}$$

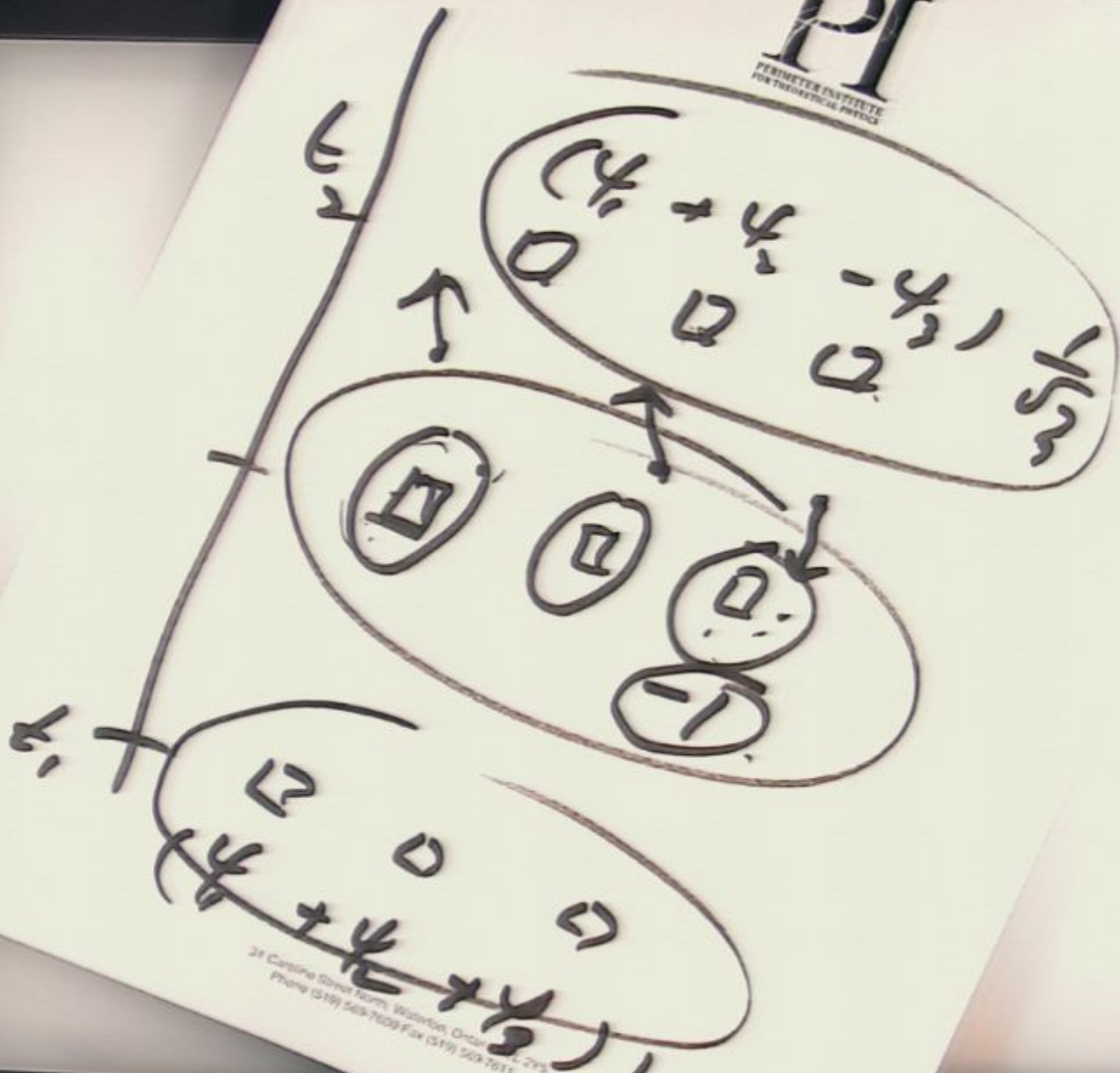




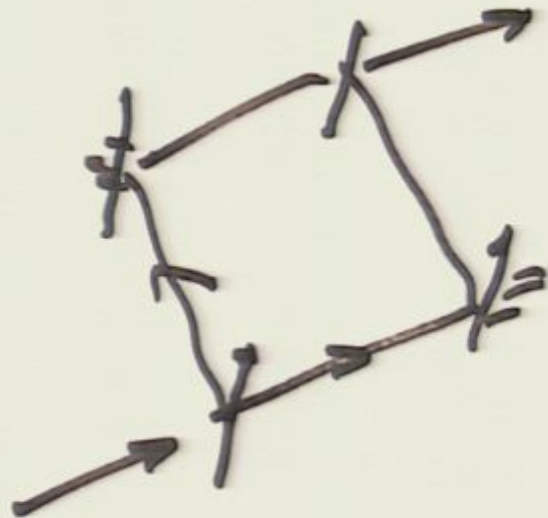
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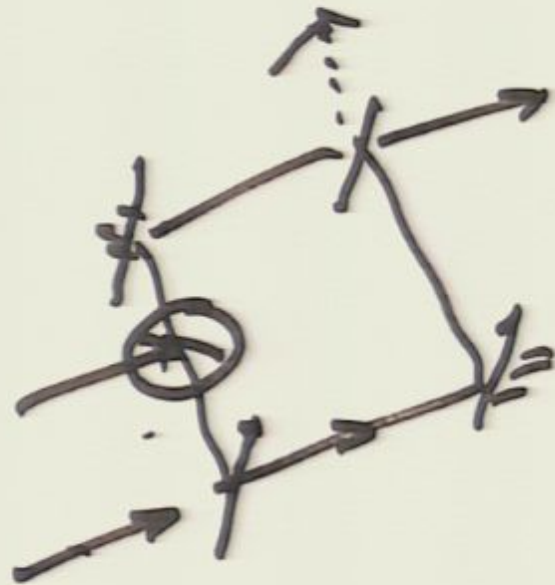


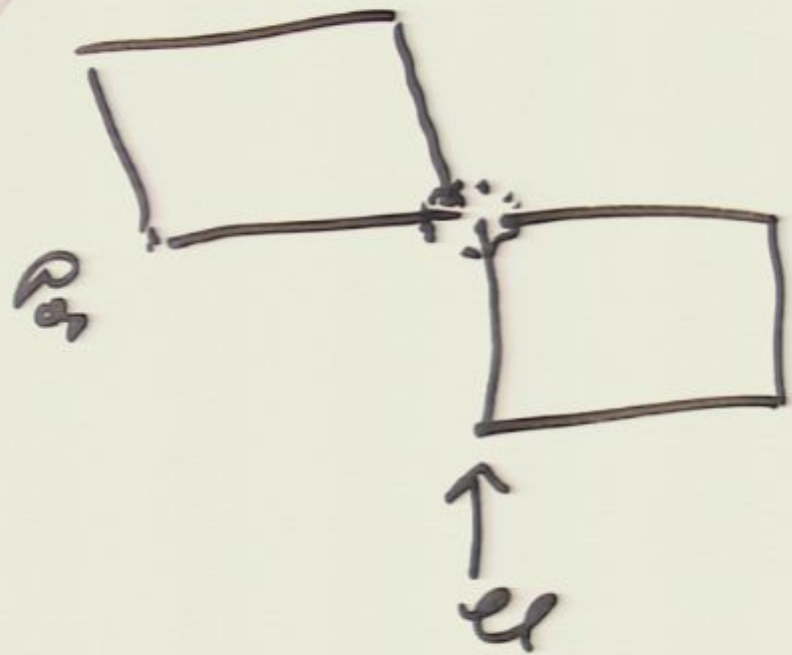


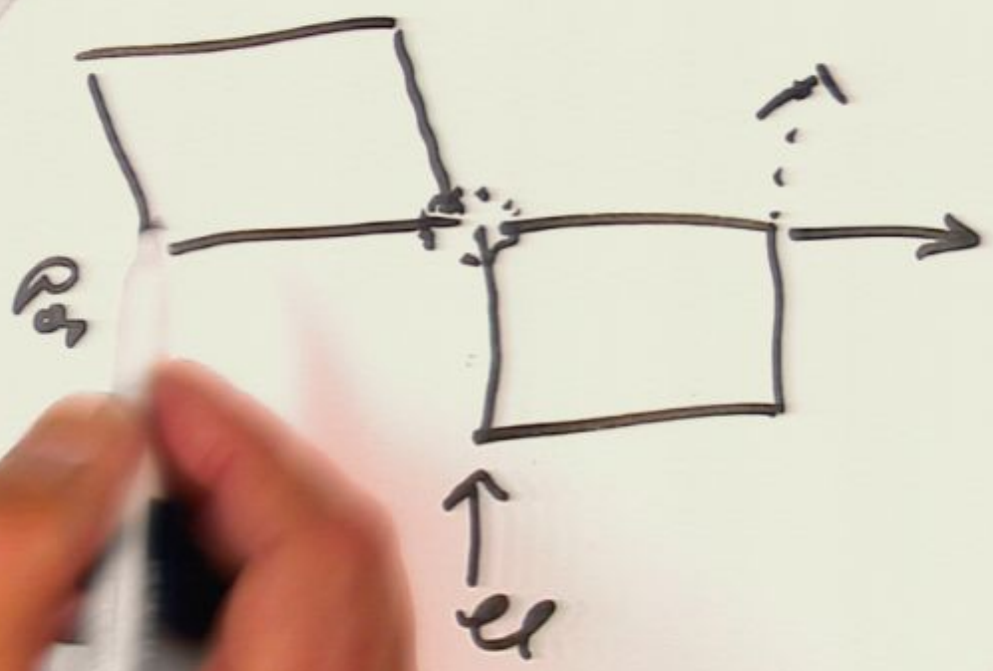


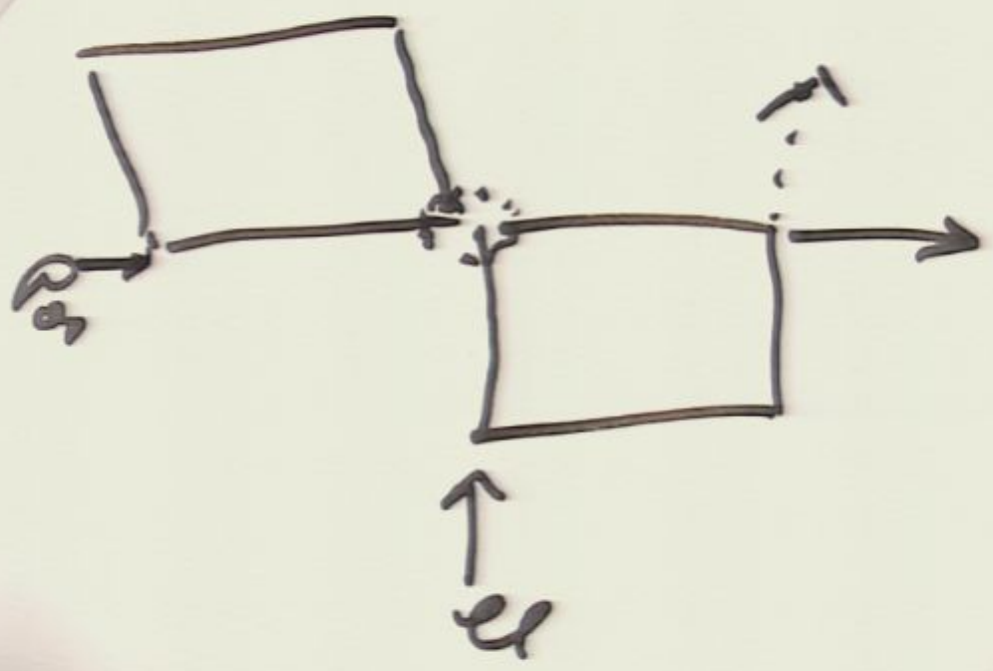


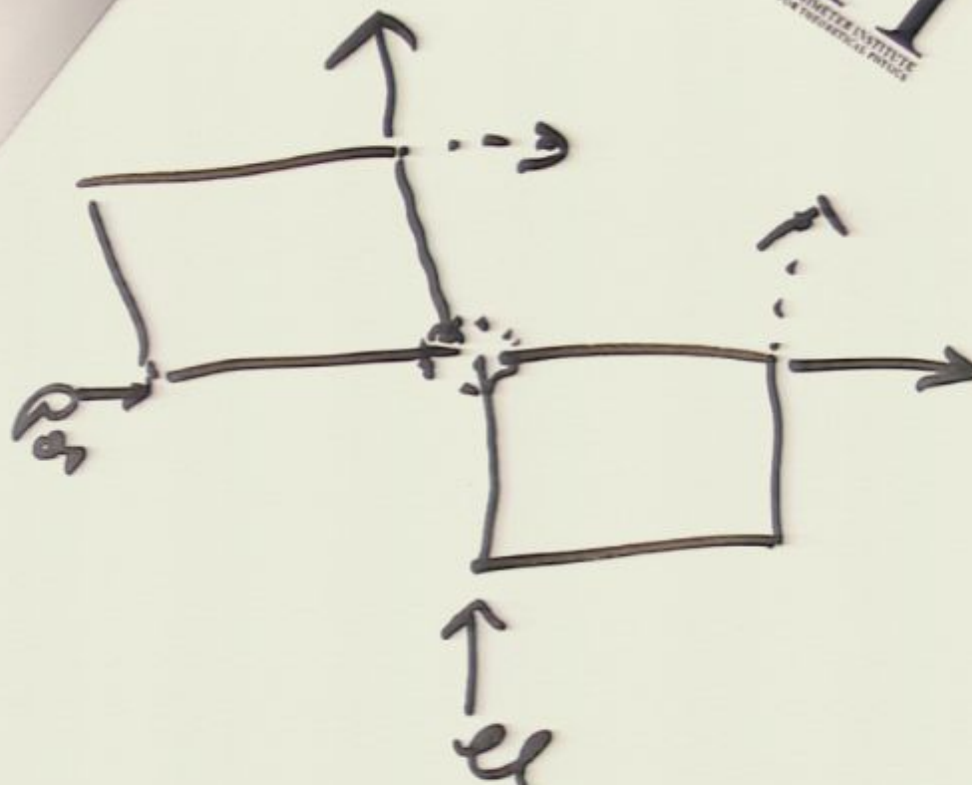


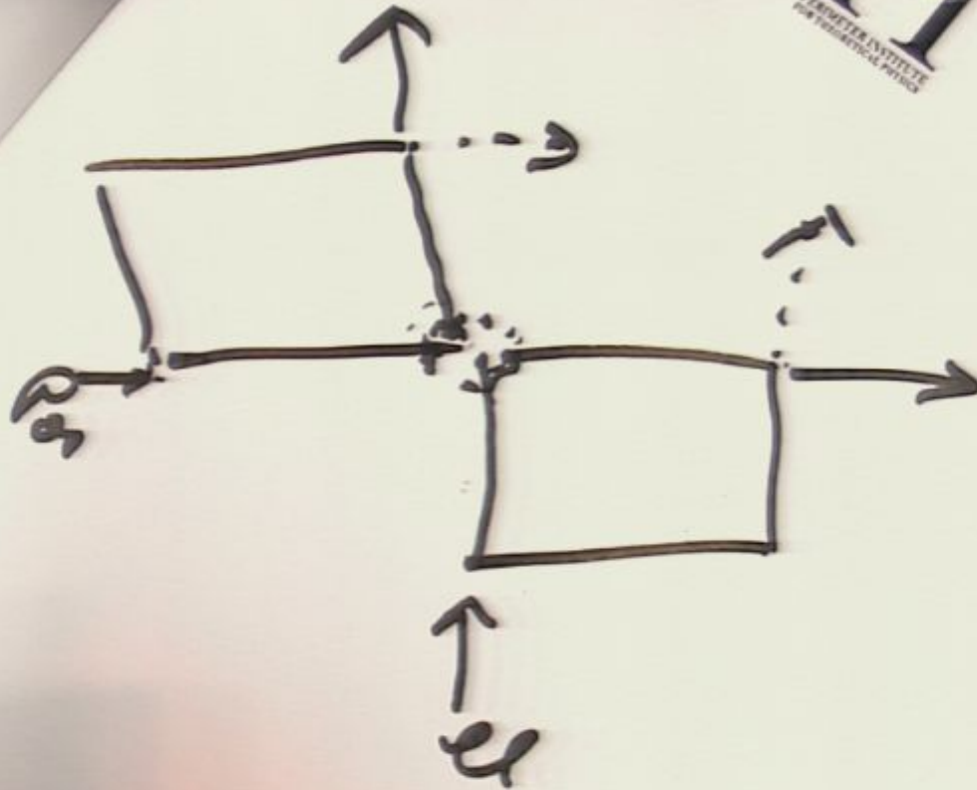


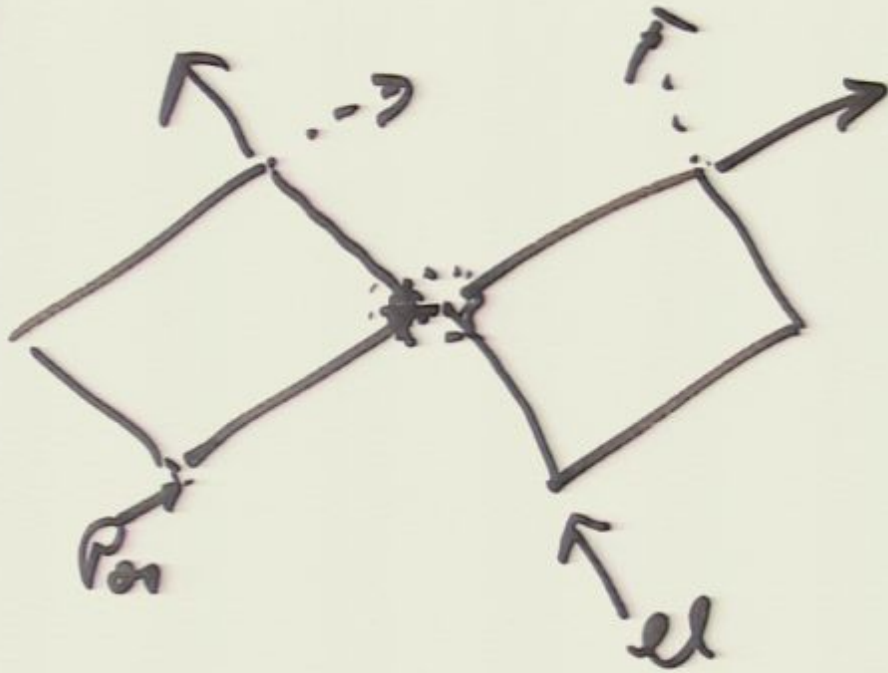


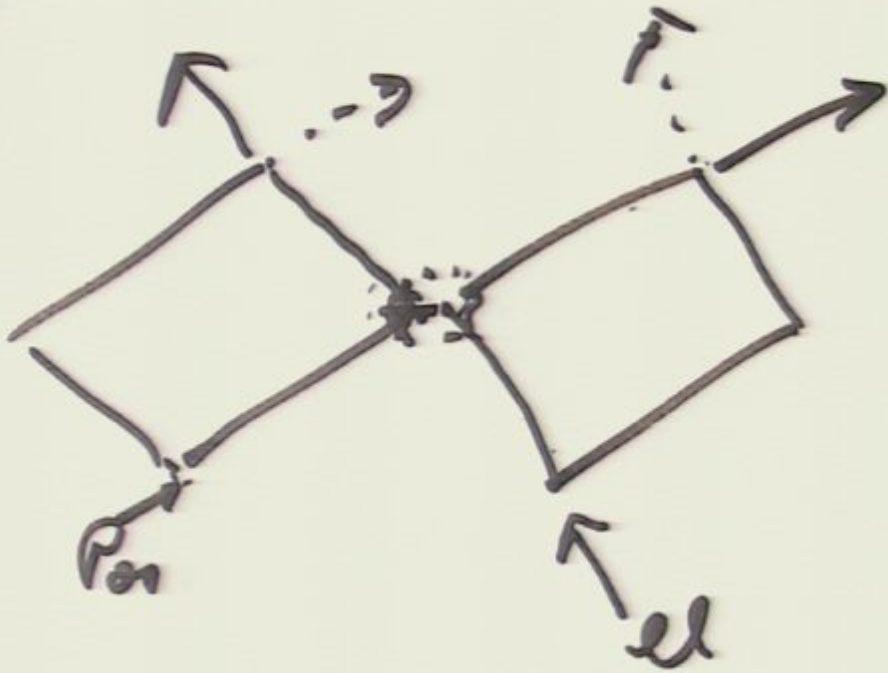




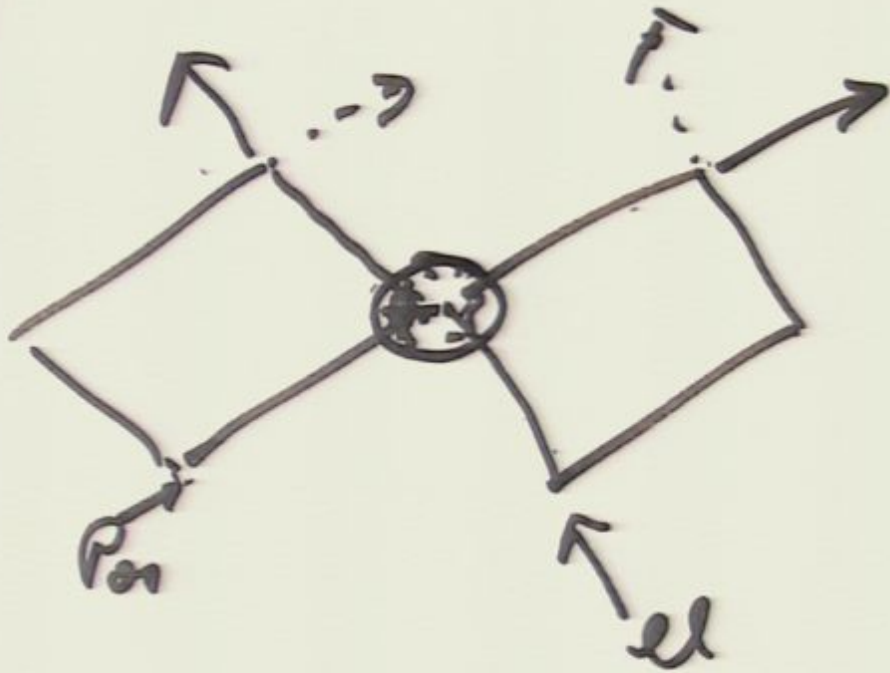


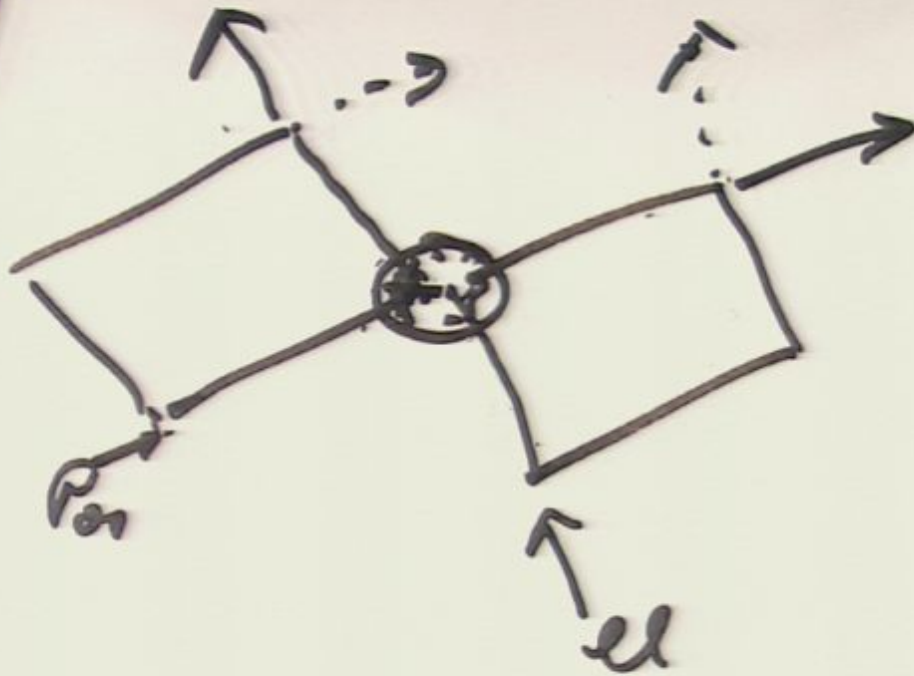




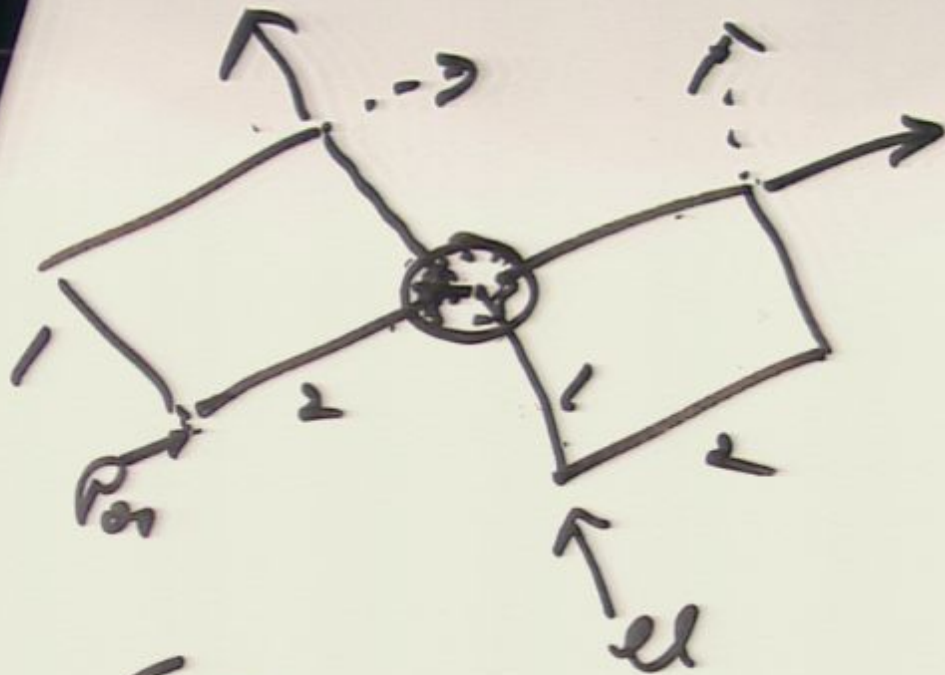






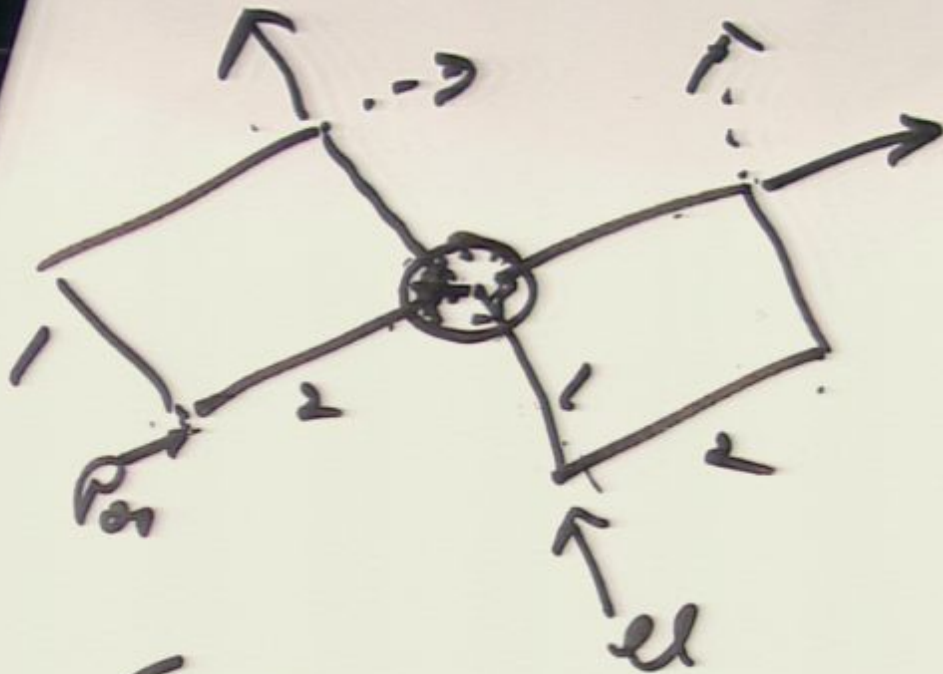


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←→ 1/2 / 2/2.

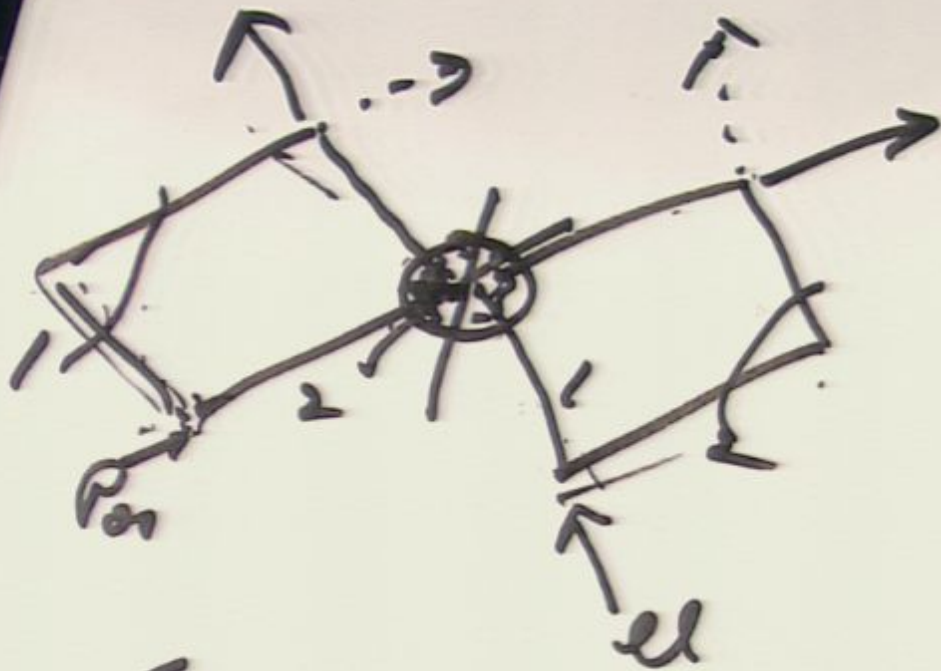
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← 474

1/27/27.

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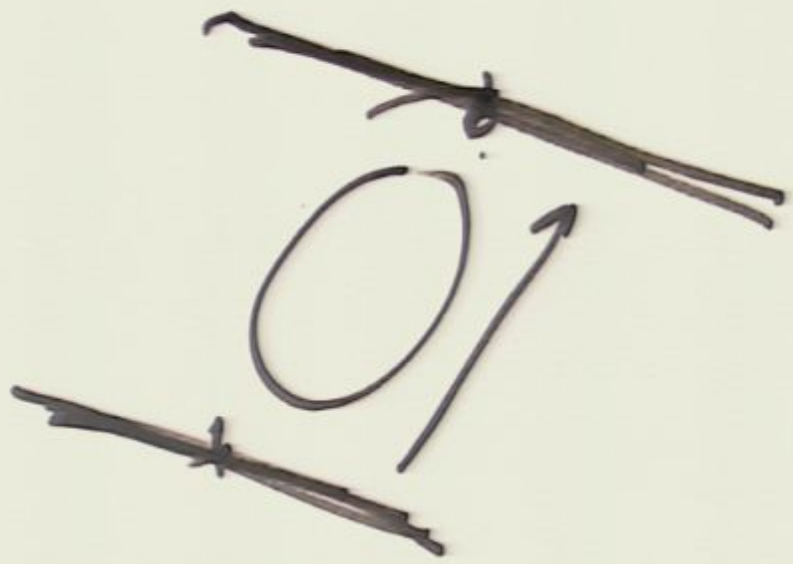
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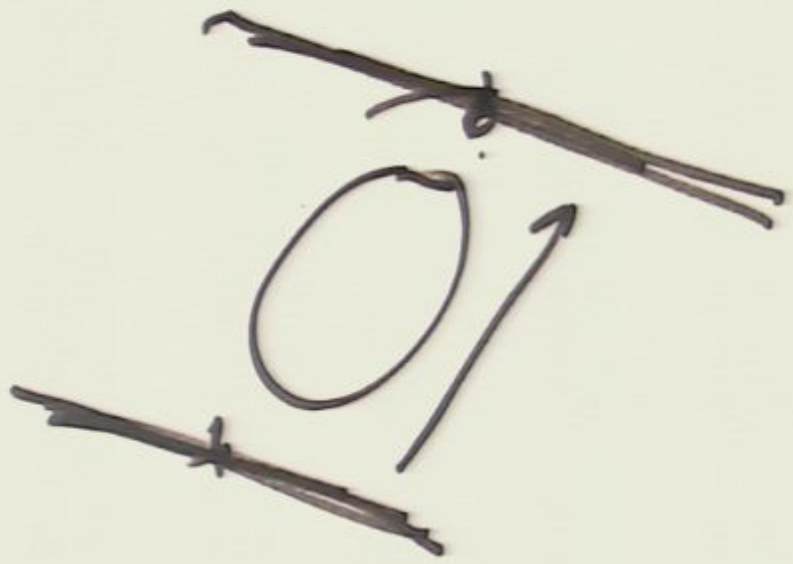
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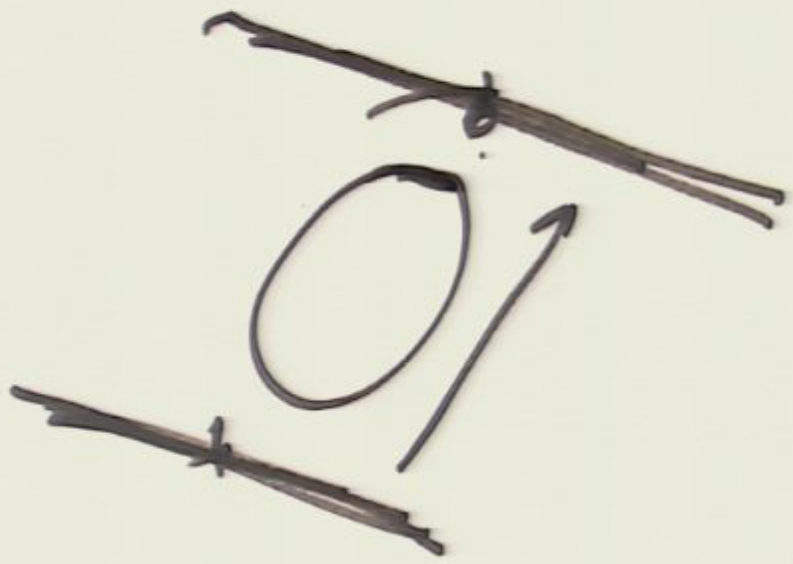


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$$\hat{A} |E_1\rangle = a |E_1\rangle$$
$$\hat{B} |E_2\rangle = b |E_2\rangle$$

$$\vec{A} |\Psi_1\rangle = a |\Psi_1\rangle$$

$$\vec{B} |\Psi_2\rangle = b |\Psi_2\rangle$$

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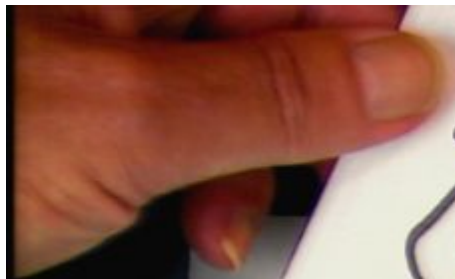
$$(\vec{A} + \vec{B}) \omega = a + b.$$

$$\hat{A} |\psi_1\rangle = a |\psi_1\rangle$$

$$\hat{B} |\psi_2\rangle = b |\psi_2\rangle$$

$$(\hat{A} + \hat{B}) \omega = a + b.$$

$$\left[ \frac{(\hat{x} - x_0)^2 + p^2}{2} \right] |\psi_1\rangle = \frac{1}{2} |\psi_1\rangle$$



$$|\vec{r}_2\rangle = e^{i\vec{p}\cdot\vec{r}_2/\hbar} |\vec{r}_1\rangle$$

$$(\vec{A} + \vec{B})\omega = a e^{i\vec{p}\cdot\vec{r}_2/\hbar}$$

$$\left[ \frac{\hbar^2 \nabla^2}{2m} + V(\vec{r}) \right] \psi = E \psi$$

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$$(A + B)\omega = a \text{ e. l.}$$

$$\left[ \frac{(x-x_1)^2 + (y-y_1)^2}{r^2} \right] = k$$

PI

$$\frac{(x-x_1)^2 + (y-y_1)^2}{r^2} = k$$

$$\frac{(x-x_2)^2 + (y-y_2)^2}{r^2} = k$$

$$(A + B)\omega = a \text{ and } \dots$$

$$\sqrt{\frac{(x-x_1)^2}{r^2} + \frac{(y-y_1)^2}{r^2}} = \dots$$

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$$\sqrt{\frac{(x-x_1)^2}{r^2} + \frac{(y-y_1)^2}{r^2}} = \dots$$

$$\sqrt{\frac{(x-x_1)^2}{r^2} + \frac{(y-y_1)^2}{r^2}} = \dots$$



$\mathcal{F}^2(x, y) \sim \frac{1}{2} x^2 y^2$

$\mathcal{F}^2(x, y) \sim \frac{1}{2} x^2 y^2$

$\sim \ln$

$\sim \ln$

$\sim \ln$

$\sim \ln$

$\sim \ln$

$\sim \ln$

$\sim \ln$



$$\frac{(x_1 - x_2)^2}{2} + \rho^2$$

$$\frac{1}{2} = \frac{1}{2} = 0$$

$$\frac{(x_1 + x_2)^2}{2} + \rho^2$$

$$\frac{1}{2} = b.$$

$$x_1^2 + \rho^2 = 1$$

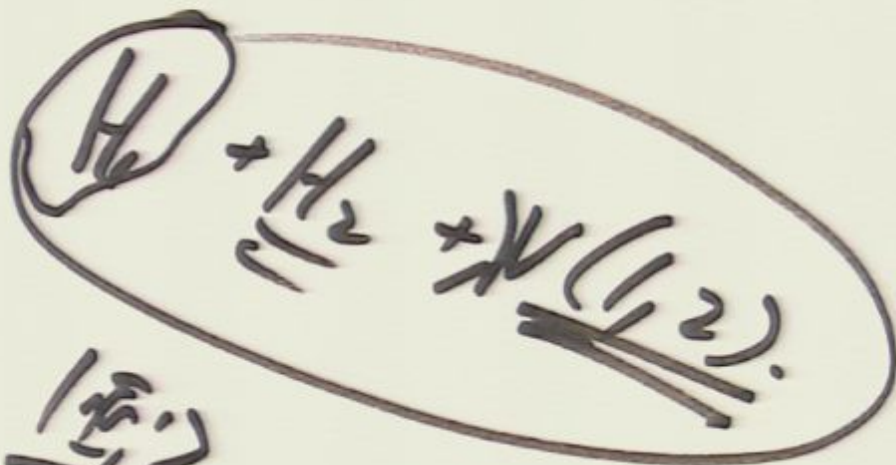
$$x_2^2 + \rho^2 = 1 - x_1^2$$



$$H_0 + H_2 + \mathcal{N}(1, 2).$$

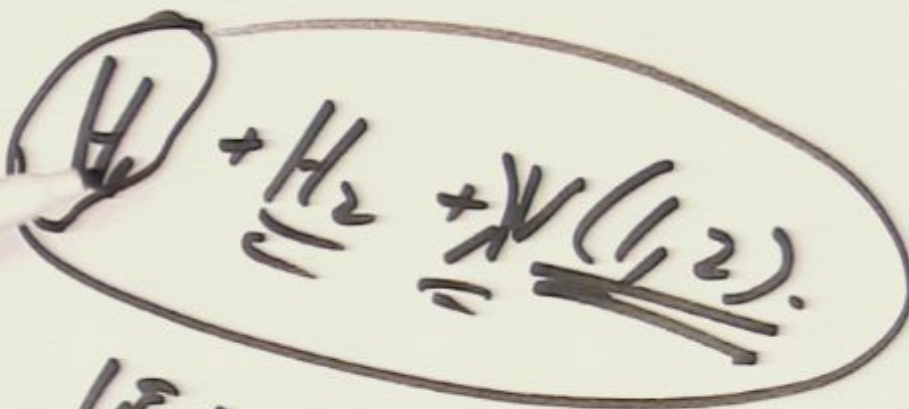
$$H_1 + \underline{H_2} + \mathcal{N}(1, 2).$$

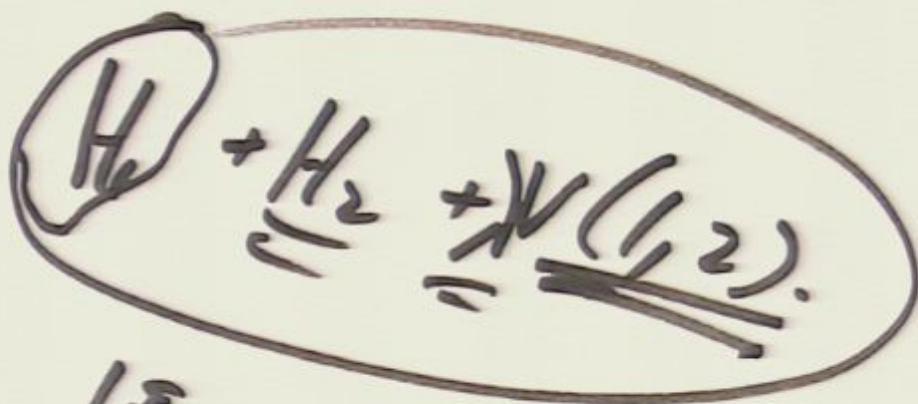
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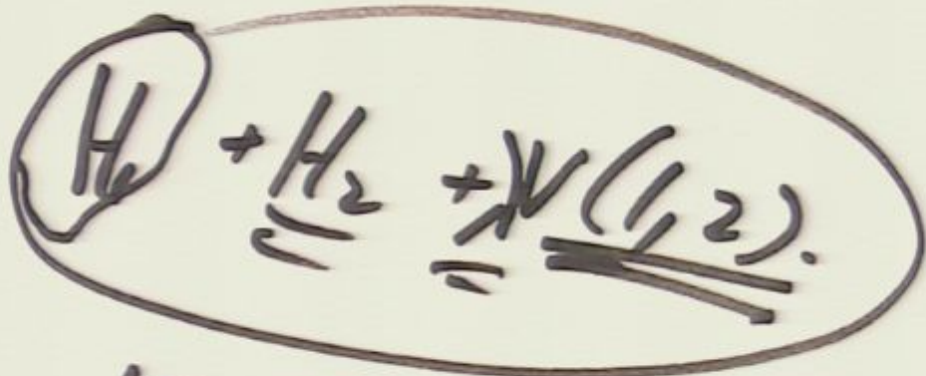
$\frac{1}{2} H_e$

$\frac{1}{2} H_e$





$V_{\omega}(2)$



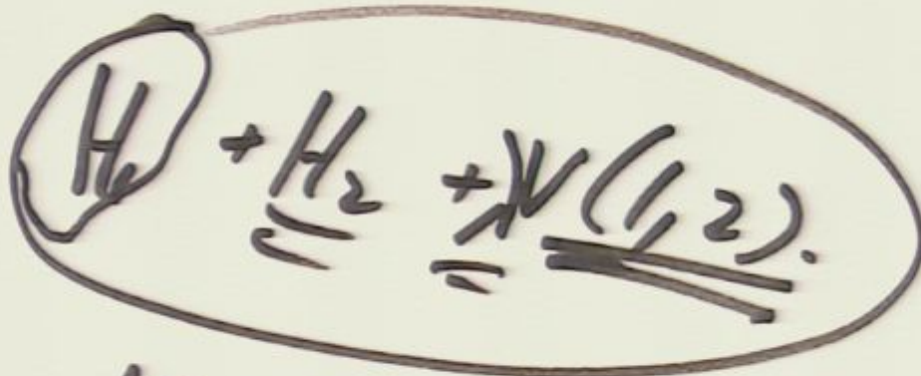
$$\begin{aligned}
 &V_{\omega}(2) \\
 &= \frac{\langle \psi_1 | V | \psi_2 \rangle}{\langle \psi_1 | \psi_2 \rangle}
 \end{aligned}$$



$$\textcircled{H_1} + \underline{H_2} + \underline{V(1,2)}$$



$$\begin{aligned}
 &V_{\omega}(2) \\
 &= \frac{\langle \psi_1 | H_2 | \psi_2 \rangle}{\langle \psi_1 | \psi_2 \rangle}
 \end{aligned}$$



$$V_{\omega}(2)$$
  

$$= \langle \psi_1 | V | \psi_2 \rangle$$
  

$$\langle \psi_1 | \psi_2 \rangle$$

$$H_0 + H_2 + V(1,2)$$



$$\begin{aligned}
 &V_{\omega}(2) \\
 &= \frac{\langle \psi_1 | V | \psi_2 \rangle}{\langle \psi_1 | \psi_2 \rangle}
 \end{aligned}$$